This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

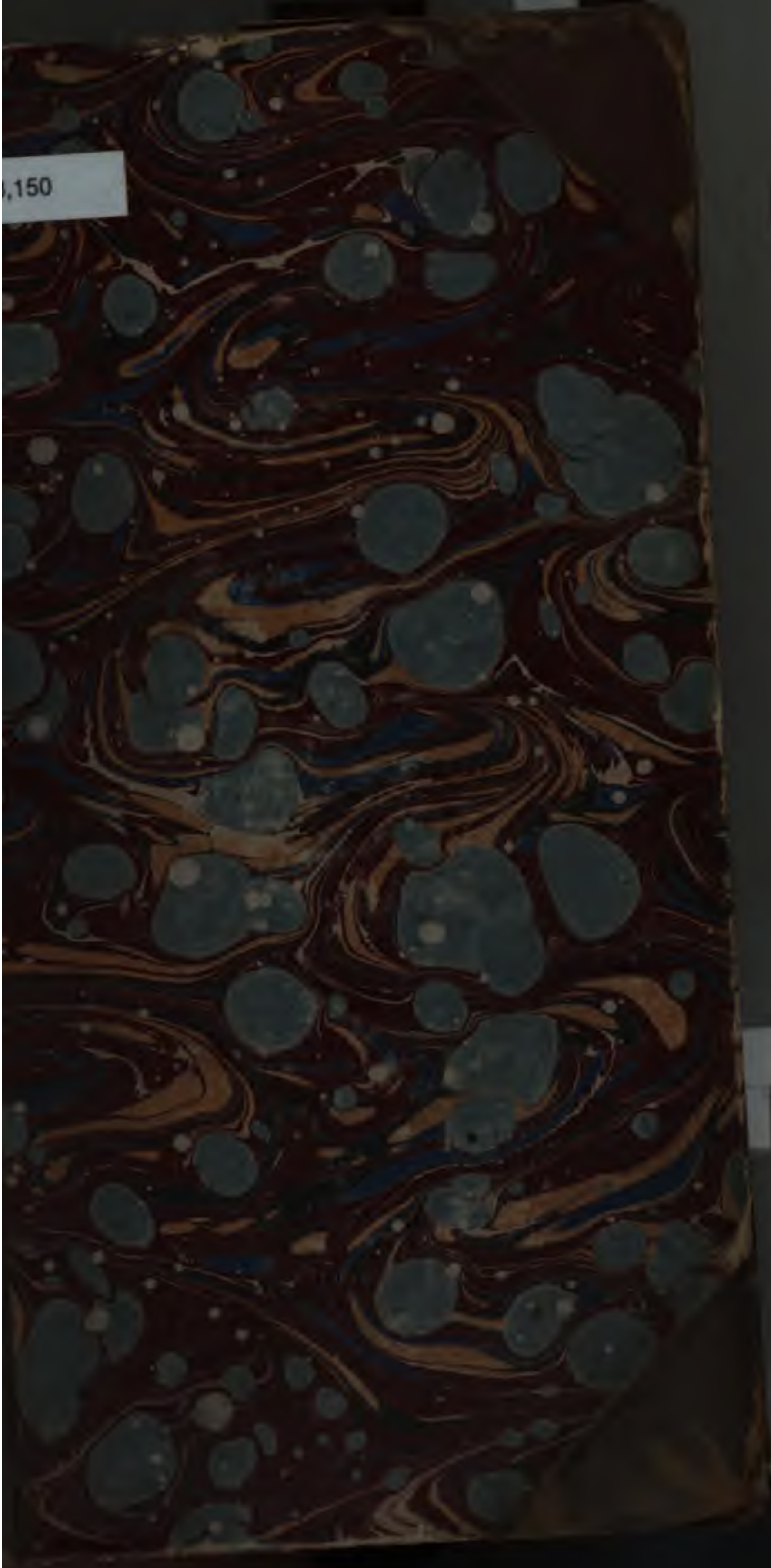
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

,150



UNIVERSITY of MICHIGAN
GENERAL LIBRARY
OCTAVIA WILLIAMS BATES
BEQUEST

9
11
447

UNIVERSITY of MICHIGAN
GENERAL LIBRARY
OCTAVIA WILLIAMS BATES
BEQUEST

NOTICES

OF THE

PROCEEDINGS

AT THE

MEETINGS OF THE MEMBERS

OF THE

Royal Institution of Great Britain,

WITH

ABSTRACTS OF THE DISCOURSES

DELIVERED AT

THE EVENING MEETINGS.

VOL. IV.

1862—1866,

WITH

INDEX TO VOL. I.-IV. (1851-66).

LONDON:
PRINTED BY WILLIAM CLOWES AND SONS,
14, CHARING CROSS.
1866.

9-27-1922
Bates

Patron.

HER MOST GRACIOUS MAJESTY
QUEEN VICTORIA.

Vice-Patron and Honorary Member,

HIS ROYAL HIGHNESS
THE PRINCE OF WALES, K.G.

President—Sir Henry Holland, Bart. M.D. D.C.L. F.R.S.
Treasurer—William Spottiswoode, Esq. M.A. F.R.S.—*V. P.*
Secretary—Henry Bence Jones, M.A. M.D. F.R.S.

Managers. 1866–67.

Warren De la Rue, Esq. Ph.D. F.R.S.
Sir George Everest, C.B. F.R.S.
John Hall Gladstone, Esq. Ph.D. F.R.S.
Wm. R. Grove, Esq. Q.C. F.R.S.—*V.P.*
Cæsar H. Hawkins, Esq. F.R.S.
Sir John Lubbock, Bt. F.R.S. Pr. Ent. S.
John Carrick Moore, Esq. M.A. F.R.S.
William Pole, Esq. M.A. F.R.S.
William Frederick Pollock, Esq. M.A.
Lewis Powell, M.D. F.S.A.
Lt.-Gen. E. Sabine, R.A. Pr. R.S.—*V.P.*
Earl Stanhope, F.R.S. Pr. S.A.—*V.P.*
Joseph William Thrupp, Esq.
Charles Wheatstone, Esq. D.C.L. F.R.S.
Colonel Philip James Yorke, F.R.S.

Visitors. 1866–67.

Sir Charles Tilston Bright, M.P.
John Charles Burgoyne, Esq.
George Frederick Chambers, Esq.
Captain James Drew
Samuel Gaskell, Esq.
Henry Harwood Harwood, Esq.
Thomas Williams Helps, Esq. M.A.
Sir Thomas Henry.
Thomas Hyde Hills, Esq.
William Edward Kilburn, Esq.
Harry Mackenzie, Esq.
Matthew Noble, Esq.
The Lord Overstone, M.A.
Thomas Harrington Tuke, M.D.
Henry Twining, Esq.

Fullerian Professor of Chemistry and Director of the Laboratory—Michael Faraday, Esq. D.C.L. LL.D. F.R.S. Foreign Associate Acad. Sciences, Paris, &c.
Fullerian Professor of Physiology—Thomas H. Huxley, Esq. F.R.S. &c.
Professor of Natural Philosophy—John Tyndall, Esq. LL.D. F.R.S. &c.
Professor of Chemistry—Edward Frankland, Esq. F.R.S. &c.

Assistant Secretary and Keeper of the Library—Mr. Benjamin Vincent.
Clerk of Accounts and Collector—Mr. William Hughes.
Assistant in the Library—Mr. Henry C. Hughes.

CONTENTS.

1862.

Page
Dec. 1.—General Monthly Meeting 1

1863.

Jan. 19.—Special Meeting—Election of H.R.H. The Prince of Wales as Honorary Member and Vice-Patron. 2
„ 23.—Professor Tyndall, F.R.S.—On Radiation through the Earth's Atmosphere 4
„ 30.—His Eminence Cardinal Wiseman—On the Points of Contact between Science and Art . . . 9
Feb. 2.—General Monthly Meeting 13
„ 6.—James Glaisher, Esq.—On Aerial Scientific Research 65
„ 13.—Professor Frankland—On Artificial Illumination 16
„ 20.—Rev. George Williams—On Recent Discoveries at Jerusalem 23
„ 27.—John Lubbock, Esq.—On the Ancient Lake-Habitations of Switzerland 29
March 2.—General Monthly Meeting 40
„ 6.—Wm. Allen Miller, M.D. Treas. R.S.—On the Photographic Transparency of Bodies, and on the Photographic Spectra of the Elementary Bodies . 42
„ 13.—Dr J. H. Gladstone—On Fogs and Fog Signals . 49
„ 20.—Balfour Stewart, Esq.—On the Forces concerned in producing Magnetic Disturbances . . . 55
„ 27.—William Crookes, Esq.—On the Discovery of the metal Thallium 62
April 6.—General Monthly Meeting 73
„ 17.—Frank Buckland, Esq.—On the Culture of Fish . 75

1863. Page
April 24.—ALEXANDER S. HERSCHEL, Esq.—On Luminous Meteors 87
May 1.—Annual Meeting 97
„ 1.—JOHN LEIGHTON, Esq.—On Japanese Art—illustrated by Native Examples 99
„ 4.—General Monthly Meeting 108
„ 8.—DR. AUGUSTUS VOELCKER—On some Chemical and Physical Properties of Soils, and the Productive Powers of the Soils of England 110
„ 15.—DR. WILLIAM ODLING—On the Molecule of Water 118
„ 22.—PROFESSOR ROSCOE—On the Direct Measurement of the Sun's Chemical Action 128
„ 29.—PROFESSOR MAX MÜLLER—On the Vedas . . 135
June 1.—General Monthly Meeting 141
„ 5.—JOHN RUSKIN, Esq.—On the Forms of the Stratified Alps of Savoy 142
„ 12.—PROFESSOR TYNDALL—An Account of some Researches on Radiant Heat 146
„ 23.—CAPTAIN SPEKE—On the Discovery of the Source of the Nile (*no Abstract*) 150
July 6.—General Monthly Meeting 151
Nov. 2.—General Monthly Meeting 153
Dec. 7.—General Monthly Meeting 155

1864.

Jan. 22.—W. R. GROVE, Esq.—On Boiling Water 158
„ 29.—PROFESSOR FRANKLAND—On the Glacial Epoch . 166
Feb. 1.—General Monthly Meeting 176
„ 5.—J. A. FROUDE, Esq.—On the Science of History . 180
„ 12.—J. ALFRED WANKLYN, Esq.—On the Synthesis of Organic Bodies 199
„ 19.—W. S. SAVORY, Esq.—On Dreaming and Somnambulism. 207
„ 26.—JOSEPH PRESTWICH, Esq.—On the Flint Implements of Abbeville 213
March 4.—PROFESSOR STOKES—On the Discrimination of Organic Bodies by their Optical Properties . . 223

1864. Page

March 7.—General Monthly Meeting 231

„ 11.—The Rev. W. H. BROOKFIELD—On Oral Reading . 241

„ 18.—PROFESSOR TYNDALL—Contributions to Molecular Physics 233

April 4.—General Monthly Meeting 243

„ 8.—Dr. JOHN PERCY—On Recent Improvements in the Smelting of Iron and the Manufacture of Steel (*no Abstract*) 244

„ 15.—PROFESSOR ABEL—On the Chemical History and Application of Gun-cotton. 245

„ 22.—PROFESSOR JOHN S. BLACKIE—On the Spartan Constitution and the Agrarian Laws of Lycurgus . 263

„ 29.—PROFESSOR ALEXANDER W. WILLIAMSON—On the Classification of the Elements in relation to their Atomicities 274

May 2.—Annual Meeting 282

„ 6.—PROFESSOR ROSCOE—On the Metal Indium, and Recent Discoveries in Spectrum Analysis . . 284

„ 9.—General Monthly Meeting 290

„ 13.—J. SCOTT RUSSELL, Esq.—On the Mechanical Nature and Uses of Gun-Cotton 292

„ 20.—JAMES NASMYTH, Esq.—On the Physical Aspects of the Moon's Surface 300

„ 27.—REGINALD S. POOLE, Esq.—On Greek Coins as illustrating Greek Art 306

June 3.—PROFESSOR FRANKLAND—On Recent Chemical Researches in the Royal Institution 309

„ 6.—General Monthly Meeting 315

„ 10.—PROFESSOR TYNDALL—On a Magnetic Experiment . 317

July 4.—General Monthly Meeting 323

Nov. 7.—General Monthly Meeting 325

Dec. 5.—General Monthly Meeting 327

1865.

Jan. 20.—PROFESSOR TYNDALL—On Combustion by Invisible Rays 329

„ 27.—Gen. SIR HENRY RAWLINSON—On the Results of Cuneiform Discovery up to the present time . 335

1865. Page
Feb. 3.—Dr. Wm. Odling—On Aluminium Ethide and Methide 343
„ 6.—General Monthly Meeting 346
„ 10.—W. Giffard Palgrave, Esq.—On Central and Eastern Arabia 348
„ 17.—[No Meeting in consequence of the decease of His Grace the President.]
„ 24.—John Evans, Esq.—On the Forgery of Antiquities. 356
March 3.—James Fergusson, Esq.—On the Holy Sepulchre and the Temple at Jerusalem 366
„ 6.—General Monthly Meeting 372
„ 10.—Professor Ramsay—On the Eozoön and the Laurentian Rocks of Canada 374
„ 17.—Balfour Stewart, Esq.—On the latest Discoveries concerning the Sun's Surface. . . 378
„ 24.—Professor Westmacott—On Art-Education, and how Works of Art should be viewed . . . 381
„ 31.—James Glaisher, Esq.—On Scientific Experiments in Balloons 385
April 3.—General Monthly Meeting 399
„ 7.—Dr. A. W. Hofmann—On the Combining Power of Atoms 401
„ 28.—Dr. Lyon Playfair—On the Food of Man in relation to his Useful Work 431
May 1.—Annual Meeting 433
„ 5.—Professor Fawcett.—On Wealth and those who produce it (*no Abstract*) 434
„ 8.—General Monthly Meeting 435
„ 12.—Frederick Field, Esq.—On Magenta and its Derivative Colours 437
„ 19.—William Huggins, Esq.—On the Physical and Chemical Constitution of the Fixed Stars and Nebulæ 441
„ 26.—Dr. Bence Jones—On the Chemical Circulation in the Body 449
June 2.—Professor Huxley—On the Methods and Results of Ethnology 461
„ 5.—General Monthly Meeting 464
„ 9.—Professor Frankland—On Researches in Organic Chemistry in the Royal Institution . . . 465

1865. Page
July 3.—General Monthly Meeting 468
CARDINAL WISEMAN—On Shakespeare . . . 470
Nov. 6.—GENERAL MONTHLY MEETING 483
Dec. 4.—GENERAL MONTHLY MEETING 485

1866.

Jan. 19.—PROFESSOR TYNDALL—On Radiation and Absorption, with reference to the Colour of Bodies, and their State of Aggregation 487
„ 26.—S. W. BAKER—On the Sources of the Nile . . 492
Feb. 2.—THE EARL STANHOPE—On the Influence of Arabic Philosophy in Mediæval Europe . . . 506
„ 5.—GENERAL MONTHLY MEETING 516
„ 9.—ARCHIBALD SMITH, Esq.—On the Deviation of the Compass in Iron Ships 518
„ 16.—COL. SIR H. JAMES—On the Ordnance Survey of Jerusalem 526
„ 23.—WILLIAM PENGELLY, Esq.—On Kent's Cavern, Torquay 534
March 2.—G. SCHARF, Esq.—On Portraiture: its Fallacies and Curiosities as connected with English History . 543
„ 5.—GENERAL MONTHLY MEETING 549
„ 9.—SIR JOHN LUBBOCK—On the Metamorphoses of Insects 551
„ 16.—BALFOUR STEWART, Esq.—On the Existence of a Material Medium pervading space . . . 558
„ 23.—DR. BENCE JONES—On the Existence in the Textures of Animals of a Fluorescent Substance closely resembling Quinine 564
April 2.—GENERAL MONTHLY MEETING 572
„ 13.—PROFESSOR DU BOIS REYMOND—On the Time required for the Transmission of Volition and Sensation through the Nerves 575
„ 20.—G. A. MACFARREN, Esq.—On the Music of the Church of England 594
„ 27.—THE DEAN OF WESTMINSTER.—On Westminster Abbey 598
May 1.—ANNUAL MEETING 615

1866. Page

May 4.—Professor Abel—On Recent Progress in the History of proposed Substitutes for Gunpowder . . 616

„ 7.—General Monthly Meeting 627

„ 11.—Professor Ansted—On the Mud Volcanoes of the Crimea, and on the relation of these and similar Phenomena to Deposits of Petroleum . . 628

„ 18.—The Rev. C. Pritchard—On the Telescope, its Modern Form, and the Difficulties of its Construction 641

„ 25.—Alexander Herschel, Esq.—On the Shooting Stars of the Years 1865–6, and on the Probability of the Cosmical Theory of their Origin . . . 645

June 1.—Professor Roscoe, F.R.S.—On the Opalescence of the Atmosphere 651

„ 4.—General Monthly Meeting 660

„ 8.—Professor Frankland—On the Source of Muscular Power 661

„ 15.—Professor Tyndall—Experiments on the Vibration of Strings 685

July 2.—General Monthly Meeting 694

Index to Volumes I.–IV. 696

Royal Institution of Great Britain.

1862.

GENERAL MONTHLY MEETING,

Monday, December 1, 1862.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

George Berkely, Esq.
Michael Smith, Esq.
John Ware Stephenson, Esq. and
Major Henry Strachey,

were *elected* Members of the Royal Institution.

August F. Andresen, Esq. and
Samuel Scott, Esq.

were *admitted* Members of the Royal Institution.

Sir Roderick I. Murchison, D.C.L. F.R.S., was elected a Manager, in the room of Sir B. C. Brodie, Bart., deceased.

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Secretary for War (through Sir H. James, the Editor)—Abstracts of the Meteorological Observations taken at the Stations of the Royal Engineers, 1860–61. 4to. 1862.

American Academy of Arts and Sciences—Memoirs, Vol. VIII. Part 1. 4to. 1861.
Proceedings, Vol. V. Nos. 31–48. 8vo. 1861–42.

American Philosophical Society—Proceedings, Nos. 62, 64, 65. 8vo. 1859–62.

Boston Society of Natural History, U.S.—Proceedings, Vol. VIII. Nos. 5–20; Vol. IX. Nos. 1–3. 8vo. 1861–2.

Brande, William Thomas, Esq. F.R.S.—Chemistry. By W. T. Brande and A. S. Taylor. 16to. 1863.

Chemical Society—Journal, No. 67. 8vo. 1862.

Cheney, T. A. Esq.—Report on the New York State Cabinet of Natural History and Antiquities. 8vo. 1860.

Editors—Artizan for November, 1862. 4to.
Athenæum for November, 1862. 4to.
Chemical News for November, 1862. 4to.
Engineer for November, 1862. fol.
Horological Journal, No. 52. 8vo. 1862.

Editors (continued)—Journal of Gas-Lighting for November, 1862. 4to.
Mechanics' Magazine for November, 1862. 8vo.
Medical Circular for November, 1862. 8vo.
Practical Mechanic's Journal for November, 1862. 4to.
Technologist for November, 1862. 8vo.
Franklin Institute of Pennsylvania—Journal. No. 442. 8vo. 1862.
Geographical Society, Royal—Proceedings. Vol. VI. No. 5. 8vo. 1862.
Geological Institute, Vienna—Jahrbuch. 1861-2. No. 3. 8vo. 1862.
Geological Society—Quarterly Journal, No. 72. 8vo. 1862.
Geological Society of Dublin—Journal. Vol. IX. Part 2. 8vo. 1861-2.
Graham, Lieut.-Col. J. D. U.S.—Report on Harbours of Lake Michigan, &c. 8vo. 1862.
Held, Joseph, Ph.D. LL.D. (the Author)—Staat und Gesellschaft. Band I. 8vo. Leipzig. 1861.
Liverpool Literary and Philosophical Society—Proceedings. No. 16. 8vo. 1862.
Medical and Chirurgical Society, Royal—Medico-Chirurgical Transactions. Vol. XLV. 8vo. 1862.
Newton, Messrs.—London Journal (New Series) for November, 1862. 8vo.
North of England Institute of Mining Engineers—Transactions. Vols. X. and XI. 8vo. 1861-2.
Petermann, A. Esq. (the Editor)—Mittheilungen aus dem Gesammtgebiete der Geographie. No. 10. 4to. 1862.
Photographic Society—Journal. No. 127. 8vo. 1862.
Royal Society of Edinburgh—Transactions, Vol. XXIII. Part 1. 4to. 1861-2.
Proceedings, Nos. 55-58. 8vo. 1861-2.
Royal Society of Literature—Transactions, Vol. VII. Part 2. 8vo. 1862.
Smithsonian Institution, Washington, U.S.—Smithsonian Miscellaneous Collections. Vols. I. II. III. IV. 8vo. 1860-2.
Smithsonian Report, 1860. 8vo.
Results of Meteorological Observations, 1854-9. Vol. I. 4to. 1861.
St. Petersburg Imperial Academy of Sciences—Mémoires, Tome IV. Nos. 1-9. 4to. 1861-2.
Bulletin, Tome IV. Nos. 11-14. 4to. 1861-2.
Tylor, Alfred, Esq. M.R.I.—Tylor, Edward B.: Anahuac; or, Mexico and the Mexicans. 8vo. 1861.
Verein zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Juli und Aug. 1862. 4to.
Wiener, M. Charles, Statuaire et Medalleur de S. M. le Roi des Pays-Bas—Medallion of the Prince Consort.

1863.

SPECIAL MEETING OF THE MEMBERS,

Monday, January 19, 1863.

WILLIAM POLE, Esq. M.A. F.R.S. Trseaurer and Vice-President, in the Chair.

The Chairman stated, that the Managers, desirous that His Royal Highness the PRINCE OF WALES should become an Honorary

Member and the Vice-Patron of the Institution, had requested Professor Faraday to communicate with His Royal Highness on the subject, which had been done by him in the following terms:—

"ROYAL INSTITUTION, *5th January*, 1863.

"TO HIS ROYAL HIGHNESS THE PRINCE OF WALES.

"May it please Your Royal Highness,

"The President, Secretary, and Managers, remembering the great grace which was done to the body, when the late Vice-Patron, His Royal Highness the Prince Consort, with yourself and the Prince your brother, favoured our Lectures with your presence, have requested me to express the hope they entertain, that Your Royal Highness will allow of your election into the position then filled by your admirable and much-loved Father. It is because I had the honour of speaking at that time in your presence, that the authorities here think I may not be unacceptable as the channel through which their earnest desire may be made known. Our most honoured Queen is our Patron; and that we may have your Royal Highness as Her and our Vice-Patron is the most earnest wish of our hearts. Remembering the past, we hope for this great grace for the future.

"With the deepest feelings of respect, I venture to sign myself,

"Your Royal Highness's faithful servant,

"M. FARADAY."

The Chairman further stated, that the following reply had been received from Lieut.-General Knollys, Comptroller of the Household and Treasurer to the Prince of Wales:—

"DEAR SIR, "SANDRINGHAM, *9th January*, 1863.

"I am directed by the Prince of Wales to acknowledge the receipt of your Letter, conveying the request of the authorities of the Royal Institution that His Royal Highness would allow Himself to be elected as its Vice-Patron, in the room of His lamented Father.

"His Royal Highness has desired me to say, that it will be a great gratification to Him, to fill so distinguished a post, and to occupy a position filled by that beloved Parent, however unequal His Royal Highness may feel to take His place. It will be no less satisfactory to Him to be in any way associated with the interests of Science. And His Royal Highness has commanded me particularly to assure you of the peculiar pleasure it will give Him to meet you again, where He has listened to you before, and derived so much instruction from your Lectures.

"I have the honour to remain, dear Sir, very truly yours,

"W. KNOLLYS.

"M. FARADAY, Esq."

Whereupon H.R.H. the PRINCE OF WALES was proposed, and unanimously elected Honorary Member, and then, by acclamation, was elected the Vice-Patron of the Royal Institution.

WEEKLY EVENING MEETING,

Friday, January 23, 1863.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

John Tyndall, Esq. F.R.S.
PROFESSOR OF NATURAL PHILOSOPHY, ROYAL INSTITUTION.

On Radiation through the Earth's Atmosphere.

Nobody ever obtained the idea of a line from Euclid's definition that it is length without breadth. The idea is obtained from a real physical line drawn by a pen or pencil, and therefore possessing width; the idea being afterwards brought, by a process of abstraction, more nearly into accordance with the conditions of the definition. So also with regard to physical phenomena; we must help ourselves to a conception of the invisible by means of proper images derived from the visible, afterwards purifying our conceptions to the needful extent. Definiteness of conceptions, even though at some expense to delicacy, is of the greatest utility in dealing with physical phenomena. Indeed it may be questioned whether a mind trained in physical research, can at all enjoy peace, without having made clear to itself some possible way of conceiving of those operations which lie beyond the boundaries of sense, and in which sensible phenomena originate.

When we speak of radiation through the atmosphere, we ought to be able to affix definite physical ideas, both to the term atmosphere and the term radiation. It is well known that our atmosphere is mainly composed of the two elements, oxygen and nitrogen. These elementary atoms may be figured as small spheres scattered thickly in the space which immediately surrounds the earth. They constitute about 99½ per cent. of the atmosphere. Mixed with these atoms we have others of a totally different character; we have the molecules, or atomic groups, of carbonic acid, of ammonia, and of aqueous vapour. In these substances diverse atoms have coalesced to form little systems of atoms. The molecule of aqueous vapour, for example, consists of two atoms of hydrogen united to one of oxygen; and they mingle as little triads among the monads of oxygen and nitrogen, which constitute the great mass of the atmosphere.

These atoms and molecules are separate; but in what sense? They are separate from each other in the sense in which the individual fishes of a shoal are separate. The shoal of fish is embraced by a common medium, which connects the different members of the shoal, and renders intercommunication between them possible. A medium also embraces our atoms; within our atmosphere exists a second, and a finer atmosphere, in which the atoms of oxygen and nitrogen hang like suspended grains. This finer atmosphere unites not only atom with atom, but star with star; and the light of all suns, and of all stars, is in reality a kind of music propagated through this interstellar air. This image must be clearly seized, and then we have to advance a step. We must not only figure our atoms suspended in this medium, but we must figure them vibrating in it. In this motion of the atoms consists what we call their heat. "What is heat in us," as Locke has perfectly expressed it, "is in the body heated nothing but motion." Well, we must figure this motion communicated to the medium in which the atoms swing, and sent in ripples through it with inconceivable velocity to the bounds of space. Motion in this form, unconnected with ordinary matter, but speeding through the interstellar medium, receives the name of Radiant Heat; and, if competent to excite the nerves of vision, we call it Light.

Aqueous vapour was defined to be an invisible gas. Vapour was permitted to issue horizontally with considerable force from a tube connected with a small boiler. The track of the cloud of condensed steam was vividly illuminated by the electric light. What was seen, however, was not vapour, but vapour condensed to water. Beyond the visible end of the jet the cloud resolved itself into true vapour. A lamp was placed under the jet at various points; the cloud was cut sharply off at that point, and when the flame was placed near the efflux orifice the cloud entirely disappeared. The heat of the lamp completely prevented precipitation. This same vapour was condensed and congealed on the surface of a vessel containing a freezing mixture, from which it was scraped in quantities sufficient to form a small snowball. The beam of the electric lamp, moreover, was sent through a large receiver placed on an air-pump. A single stroke of the pump caused the precipitation of the aqueous vapour within, which became beautifully illuminated by the beam; while, upon a screen behind, a richly-coloured halo due to diffraction by the little cloud within the receiver flashed forth.

The waves of heat speed from our earth through our atmosphere towards space. These waves dash in their passage against the atoms of oxygen and nitrogen, and against the molecules of aqueous vapour. Thinly scattered as these latter are, we might naturally think meanly of them as barriers to the waves of heat. We might imagine that the wide spaces between the vapour molecules would be an open door for the passage of the undulations; and that if those waves were at all intercepted, it would be by the substances which form 99½ per cent. of the whole atmosphere. Three or four years ago, however, it was found by the speaker that this small modicum of aqueous vapour intercepted fifteen times the quantity of heat stopped by the whole of the air in which it was diffused. It was afterwards found that the dry air then experimented with was not perfectly pure, and that the purer the air became the more it approached the character of a vacuum, and the greater, by comparison, became the action of the aqueous vapour. The vapour was found to act with 30, 40, 50, 60, 70 times the energy of the air in which it was diffused; and no doubt was entertained that the aqueous vapour of the air which filled the Royal Institution theatre, during the delivery of the discourse, absorbed 90 or 100 times the quantity of radiant heat which was absorbed by the main body of the air of the room.

Looking at the single atoms, for every 200 of oxygen and nitrogen there is about 1 of aqueous vapour. This 1, then, is 80 times more powerful than the 200; and hence, comparing a single atom of oxygen or nitrogen with a single atom of aqueous vapour, we may infer that the action of the latter is 16,000 times that of the former. This was a very astonishing result, and it naturally excited opposition, based on the philosophic reluctance to accept a result so grave in consequences before testing it to the uttermost. From such opposition a discovery, if it be worth the name, emerges with its fibre strengthened; as the human character gathers force from the healthy antagonisms of active life. It was urged, that the result was on the face of it improbable; that there were, moreover, many ways of accounting for it, without ascribing so enormous a comparative action to aqueous vapour. For example, the cylinder which contained the air in which these experiments were made, was stopped at its ends by plates of rocksalt, on account of their transparency to radiant heat. Rocksalt is hygroscopic; it attracts the moisture of the atmosphere. Thus, a layer of brine readily forms on the surface of a plate of rocksalt; and it is well known that brine is very impervious to the rays of heat. Illuminating a polished plate of salt by the electric lamp, and casting, by means of a lens, a magnified image of the plate upon a screen, the speaker breathed through a tube for a moment on the salt; brilliant colours of thin plates (soap-bubble colours) flashed forth immediately upon the screen — these being caused by the film of moisture which overspread the salt. Such a film, it was contended, is formed when undried air is sent into the cylinder; it was, therefore, the absorption of a layer of brine which was measured, instead of the absorption of aqueous vapour.

This objection was met in two ways. Firstly, by showing that the plates of salt when subjected to the strictest examination show no trace of a film of moisture. Secondly, by abolishing the plates of salt altogether, and obtaining the same results in a cylinder open at both ends.

It was next surmised, that the effect was due to the impurity of the London air, and the suspended carbon particles were pointed to as the cause of the opacity to radiant heat. This objection was met by bringing air from Hyde Park, Hampstead Heath, Primrose Hill, Epsom Downs, a field near Newport in the Isle of Wight, St. Catharine's Down, and the sea-beach near Black Gang Chine. The aqueous vapour of the air from these localities intercepted at least seventy times the amount of radiant heat absorbed by the air in which the vapour was diffused. Experiments made with smoky air proved that the suspended smoke of the atmosphere of West London, even when an east wind pours over it the smoke of the city, exerts only a fraction of the destructive powers exercised by the transparent and impalpable aqueous vapour diffused in the air.

The cylinder which contained the air through which the calorific rays passed was polished within, and the rays which struck the interior surface were reflected from it to the thermo-electric pile which measured the radiation. The following objection was raised :—You permit moist air to enter your cylinder; a portion of this moisture is condensed as a liquid film upon the interior surface of your tube; its reflective power is thereby diminished; less heat therefore reaches the pile, and you incorrectly ascribe to the absorption of aqueous vapour an effect which is really due to diminished reflection of the interor surface of your cylinder.

But why should the aqueous vapour so condense? The tube within is warmer than the air without, and against its inner surface the rays of heat are impinging. There can be no tendency to condensation under such circumstances. Further, let five inches of undried air be sent into the tube—that is, one-sixth of the amount which it can contain. These five inches produce their proportionate absorption. The driest day, on the driest portion of the earth's surface, would make no approach to the dryness of our cylinder when it contains only five inches of air. Make it 10, 15, 20, 25, 30 inches: you obtain an absorption exactly proportional to the quantity of vapour present. It is next to a physical impossibility that this could be the case if the effect were due to condensation. But lest a doubt should linger in the mind, not only were the plates of rock-salt abolished, but the cylinder itself was dispensed with. Humid air was displaced by dry, and dry air by humid in the free atmosphere; the absorption of the aqueous vapour was here manifest, as in all the other cases.

No doubt, therefore, can exist of the extraordinary opacity of this substance to the rays of obscure heat; and particularly such rays as are emitted by the earth after it has been warmed by the sun. It is perfectly certain that more than ten per cent. of the terrestrial radiation from the soil of England is stopped within ten feet of the surface of the soil. This one fact is sufficient to show the immense influence which this newly-discovered property of aqueous vapours must exert on the phenomena of meteorology.

This aqueous vapour is a blanket more necessary to the vegetable life of England than clothing is to man. Remove for a single summer-night the aqueous vapour from the air which overspreads this country, and you would assuredly destroy every plant capable of being destroyed by a freezing temperature. The warmth of our fields and gardens would pour itself unrequited into space, and the sun would rise upon an island held fast in the iron grip of frost. The aqueous vapour constitutes a local dam, by which the temperature at the earth's surface is deepened: the dam, however, finally overflows, and we give to space all that we receive from the sun.

The sun raises the vapours of the equatorial ocean; they rise, but for a time a vapour screen spreads above and around them. But the higher they rise, the more they come into the presence of pure space; and when, by their levity, they have penetrated the vapour screen, which lies close to the earth's surface, what must occur?

It has been said that, compared atom for atom, the absorption of an atom of aqueous vapour is 16,000 times that of air. Now the power to absorb and the power to radiate are perfectly reciprocal and proportional. The atom of aqueous vapour will therefore radiate with 16,000 times the energy of an atom of air. Imagine then this powerful radiant in the presence of space, and with no screen above it to check its radiation. Into space it pours its heat, chills itself, condenses, and the tropical torrents are the consequence. The expansion of the air, no doubt, also refrigerates it; but in accounting for those deluges, the chilling of the vapour by its own radiation must play a most important part. The rain quits the ocean as vapour; it returns to it as water. How are the vast stores of heat set free by the change from the vaporous to the liquid condition disposed of? Doubtless in great part they are wasted by radiation into space. Similar remarks apply to the cumuli of our latitudes. The warmed air, charged with vapour, rises in columns, so as to penetrate the vapour screen which hugs the earth; in the presence of space, the head of each pillar wastes its heat by radiation, condenses to a cumulus, which constitutes the visible capital of an invisible column of saturated air.

Numberless other meteorological phenomena receive their solution, by reference to the radiant and absorbent properties of aqueous vapour. It is the absence of this screen, and the consequent copious waste of heat, that causes mountains to be so much chilled when the sun is withdrawn. Its absence in Central Asia renders the winter there almost unendurable; in Sahara the dryness of the air is sometimes such, that though during the day "the soil is fire and the wind is flame," the chill at night is painful to bear. In Australia, also, the thermometric range is enormous, on account of the absence of this qualifying agent. A clear day, and a dry day, moreover, are very different things. The atmosphere may possess great visual clearness, while it is charged with aqueous vapour, and on such occasions great chilling cannot occur by terrestrial radiation. Sir John Leslie and others have been perplexed by the varying indications of their instruments on days equally bright—but all these anomalies are completely accounted for by reference to this newly-discovered property of transparent aqueous vapour. Its presence would check the earth's loss; its absence, without sensibly altering the transparency of the air, would open wide a door for the escape of the earth's heat into infinitude.

[J. T.]

WEEKLY EVENING MEETING,

Friday, January 30, 1863.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

His Eminence Cardinal Wiseman

On the Points of Contact between Science and Art.

In his preliminary observations, the Cardinal stated that, in speaking of Science and Art, he wished to extend the meaning of one of these words to the utmost, and to restrict that of the other. By Science he wished to understand whatever knowledge has come to man as the result of his investigations by thought, calculation, and experiment; by Art, he meant not the arts of life—the practical arts—but the Fine Arts, and even these restricted to the Arts of Design. As an example of their union, he referred to our three great museums, where the objects of science are almost always to be found blended or associated with objects of art. The great artist, Leonardo da Vinci, is a "representative man" of this union; but though so well known as a consummate painter, he is comparatively little acknowledged as a man of science. Yet he finds his place in the history and philosophy of the inductive sciences as a practical reformer, and has left behind thirteen volumes of scientific sketches connected with mechanics and hydraulics. It has been said also of the late Prince Consort, that he never saw Art without Science, and never looked at Science without seeing Art; and that he seized every opportunity of inculcating the necessity of cultivating the two harmoniously and inseparably, yet also independently.

The Arts of Design treated of were Painting, Sculpture, and Architecture.

Painting.—The most obvious point of contact between painting and practical science is Perspective, which signifies the art of representing on a flat surface objects which are supposed to be on different planes, or at varying distances, so as to give them, by the gradation of proportion and colour, the appearance to the eye which they would have if they were real substances. This science, by no means old, is of uncertain origin. At the Revival, its principles were observed and acted upon by the great painters by intuition; but it was long before the rules of perspective can be said to have pervaded the whole art. Attention to scientific and artistic perspective began simultaneously in Belgium and Italy,—in the schools of Van Eyck, in Belgium, and of

Giotto in Italy. In the works of the Van Eycks—(Hubert died in 1426 and John in 1446)—great improvements appear in lineal and aerial perspective, which were much advanced also by the Giotteschi, of Florence, &c. But the true history of Scientific Perspective begins with Michelangelo, in whose works the anticipations of art are verified by science, and reduced to unvarying rule.* Leonardo da Vinci (who died in 1519), and Albert Dürer (who died in 1528), a mathematician as well as painter, were also worthy agents in this great advancement of art. It was not, however, till 1608 that Guido Ubaldo published the first satisfactory treatise on Perspective. In 1642, F. Dubreuil edited his 'Prospectiva Practica,' well known as 'The Jesuit's Perspective'; and, finally, in 1731 the mathematical theory of perspective was conclusively demonstrated by Brook Taylor. These certain principles gradually became so fixed, that it was impossible afterwards to allow deviation from them. The theorems were converted into practical rules, which are now accepted for all useful purposes, without further proof; and perspective was reduced to scientific principles, which are now popularized and adopted as an essential part of artistic education.

As means of proceeding still further in educating the public eye and mind, attention was called to the greatly increased facilities which the railway, a creation of science, has afforded us for studying the beautiful in nature, and of gratifying our love of landscape in our own country and abroad.

In regard to Colour, there is, most certainly, a want of more contact between Science and Art. Some of the colours on the mural paintings of the ancients are still fresh, after an interval of eighteen hundred years; and the frescoes of the first periods of modern art, though much decayed, yet promise to remain at least distinguishable for a very much longer period. Surely, with the accurate knowledge which chemistry gives us, we ought to obtain effects not inferior to those produced by the older painters almost by accident. Science must come to the aid of art, and answer the question—"Is there any atmospherical, or other chemical action, in this country, which prevents our carrying out in it such public works of art as exist in other countries?"—In regard to Mosaics, it was stated, that in the great Vatican studio the progression of new colours and shades are entirely in the hands of a chemist, who commands and directs the laboratories and finances requisite for the work. In the 'catalogue,' the graduated specimens of colours number upwards of twenty thousand.

In SCULPTURE, one point of contact with science is in pure Mathematics. From the time of Michelangelo, though undoubtedly the feeling is much more ancient, there has been an expression of the thought, that the human figure is perfect in its proportions, and that those proportions must have a law. It has been since shown that the whole of this figure is ruled by lines, the angles of which are harmonic —so musical that they may be represented by tonic mediant and dominant; and that the curves which circumscribe the subdivisions possess this quality no less than the angles. It is interesting to find that the curve which dominates through the structure of man is the curve which rules the heavens—the ellipse.*

---

* For details on this subject, see De Morgan's "Notes on Perspective," in the *Athenæum* for October and November, 1861.

A necessary connection exists between Sculpture (and no less Painting) and the science of Anatomy. In the ancient Grecian marbles we perceive a striking contrast: we see heads of magnificent placidity, and of grandeur of organisation; heads of surpassing intellectuality united to bodies apparently of exaggerated muscularity and salient framework. There were clearly two types familiar to the Grecian artist—the men of thought, the philosopher, poet, and orator; and the athletes, whose bodies were subjected to gymnastic training. No doubt the conflicts in the arena, in which all the muscles of the body were brought into various and violent actions, were frequently witnessed and noted by the keen eye of the ancient sculptor, who had not the opportunity that artists now enjoy, of studying calmly the same muscles upon the dissected corpse, or even upon casts taken from it. Galen himself was obliged to study the ape, in order to come to his approximating knowledge of human anatomy. The Greek or Roman arrived at the knowledge of the interior construction of the figure, by what he saw without; the modern may learn directly what is concealed by the outward integuments and represent its external action.

The modern science of Ethnography, which classifies the different types of races and nations, and at the same time pays attention to the habits, manners, and customs of different countries, is also a most desirable adjunct to both branches of representative art. Great poets have shown themselves to be not above studying common subjects, or the mechanical operations of practical science, when they had to introduce them into their verses (*e.g.* Schiller, in the "Song of the Bell"); so our conclusion must be, that a great artist should despise no branch of knowledge, but should endeavour to acquire every variety of it. "*Ut pictura poesis*—as painting so is poetry," says Horace, and adds—

"Ego nec studium sine divite vena,
Nec rude quid possit video ingenium; alterius sic
Altera poscit opem res, et conjurat amice." †

Of ARCHITECTURE, as a fine art, we may repeat what has been said of the human figure; the proportions and parts of its perfect productions are no less tonic or musical: lines and angles—there being here no curves—are reducible to the same harmonic scale. This has been shown to be the case in the Parthenon, the grandest of all classical edifices; and also in Lincoln and Salisbury cathedrals.—Science, however, comes directly into contact with Architecture in the Constructive element—in the value and fitness of the materials employed in building. The necessity for this is but too evident in the disintegration of the stone of which the new Houses of Parliament are built. A commission, comprising architects, chemists, and geologists, was formed to select the best stone for the building; but the recommendation of the men of science was not carried out; and in 1861, it was said before a committee—"We" (the builders) "did not look at the stone with the eyes of chemists; we looked at it as builders." The committee, therefore, recommended that a series of chemical experiments (with the view of arresting the decay) should be conducted under *chemical supervision.* 2. Science comes also into contact with Architecture in the adjustment of weight and support — the balancing of the parts of a building. In the first stages of architecture, we are struck with the massiveness of construction—in the old Grecian, the Roman, the Etruscan, and in the Norman. This ponderous solidity was probably due to timidity and ignorance. As science advanced, architecture became slimmer. In the sixteenth century, the architects considerably lightened their style; altering the old Norman arch into the pointed, and the round massive piers into clustered columns; thus cutting out masses of sustaining material without apprehension of insecurity.—A striking example of the most salutary, because uncontrolled intervention of science in a matter relating to architecture occurred in the history of St. Peter's, at Rome. Although the architect, Michelangelo, had taken the greatest precaution for the security of the dome, yet in 1681 numerous cracks appeared in various directions through the cupola. Marble dovetails placed across the crack broke with alarming rapidity, and it was feared that in a few years the whole dome might fall in. Various remedies were suggested by architects; but the Pope Benedict XIV. wisely observed that this was not the business of Art but of Science. A commission of three eminent mathematicians (Boscovich, Le Sueur, and Jacquier) was appointed to examine the case. In 1742 they issued their report, showing by their calculations, that the entire dome with its lantern came to the weight of 55,248 tons, and that there was a balance of 1674 tons on the side of pressure against support; concluding with the remark, "that irreparable ruin must be apprehended, unless a timely and efficient remedy was applied." The remedy they proposed was entirely scientific—to put six more solid iron girders round the huge periphery of 420 feet. No time was lost. In 1743 two girders were braced round the drum, and in 1744 three more were added. We have here a notable instance of Science coming to the rescue of Art in one of its most painful crises. The proposed cure fully answered; and now, after 120 years, no sign has been given of subsequent damage.

---

* See 'The Principles of Beauty.' By John A. Symonds, M.D. 1857.

† "I see not what, without true genius, study,
Nor genius without study, can effect.
Each needs each; both, when hand in hand, will thrive."
Art of Poetry, 409.

In the concluding remarks, the Cardinal made reference to the advantages Science may derive from Art; an example of which occurs in the assistance which astronomy has obtained from photography—portraits of the sun and moon, and other celestial bodies, having been thus taken by Mr. Warren De la Rue.

GENERAL MONTHLY MEETING,

Monday, February 2, 1863.

WILLIAM POLE, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The following letter from Lieut.-General Knollys to his Grace the President was read:—

"SANDRINGHAM, NORFOLK,
"23*rd Jan.* 1863.

"MY LORD DUKE,

"I have the honour to acknowledge the receipt of your Grace's letter of the 22nd inst. transmitting, as President of the Royal Institution, a Resolution passed unanimously by that body, to the effect that His Royal Highness the Prince of Wales was elected an Honorary Member and Vice-Patron of the Royal Institution of Great Britain.

"His Royal Highness has directed me to request your Grace to express to the Members of the Royal Institution the high gratification He experienced at receiving this announcement; and in conveying his thanks, His Royal Highness desires to assure both your Grace and them of the pride He shall feel in occupying not only so honourable a post, but one that has been so distinguished by its connection with his lamented Father.

"I have the honour to be, my Lord Duke,
"Your most obedient servant,
"W. KNOLLYS.

"HIS GRACE THE DUKE OF NORTHUMBERLAND, K.G.
&c. &c. &c."

The Earl of Clanwilliam,
Edward W. Cox, Esq.
Sir William Augustus Fraser, Bart.
General Charles H. Hamilton, C.B. and
Peter Vanderbyl, Esq.

were *elected* Members of the Royal Institution.

Michael Smith, Esq.

was *admitted* a Member of the Royal Institution.

The Special Thanks of the Members were returned to—

The Executors of the late J. Walker, Esq. C.E. D.C.L. F.R.S. M.R.I. for their Present to the Institution of a Marble Bust of Professor Faraday, by Mr. Matthew Noble, M.R.I.; and to—

Mrs. Barlow, for her Second Annual Donation of Five Guineas.

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Governor-General of India—Geological Survey of India—Annual Report, 1861-2. 8vo.

Memoirs, Vol. IV. Part 2. 1862. 8vo.

Palæontologica Indica. Part 2. 4to. 1862.

Secretary of State for India—Meteorological and Magnetical Observations at Bombay, in 1860. 4to. 1861.

American Philosophical Society—Transactions. New Series. Vol. XII. Part 2. 4to. 1862.

Proceedings. No. 67. 8vo. 1862.

Astronomical Society, Royal—Monthly Notices, Nos. 1, 2. 8vo. 1862-3.

Asiatic Society of Bengal—Journal, No. 286. 8vo. 1862.

Barlow, The Rev. John, M.A. F.R.S.—The Bishop of Labuan. By Spencer St. John. 8vo. 1862.

Bavarian Academy, Royal—Sitzungsberichte, 1862. Band I. Heft 1-4. Band II. Heft 1 & 2. 8vo.

Callender, G. W. Esq. (the Author)—Anatomy of the Parts concerned in Femoral Rupture. 8vo. 1863.

Casa Loring, Marquis de—Fac-Simile of Inscriptions on Two Roman Brass Tablets found near Malaga, in Spain; lithographed at the expense of the Marquis. Edited by Dr. Em. Rod. de Berlanga. [In Portfolio III.] (See a Memoir by T. Mommsen, in Vol. III. of Abhandlungen der Kön. Sachsischen Gesellschaft.)

Chambers, G. F. Esq. M.R.I.—J. Powles, New Granada: its Internal Resources (K 89) 8vo. 1862.

Chemical Society—Quarterly Journal, New Series, No. 1. 8vo. 1863.

Civil Engineers, Institution of—Minutes of Proceedings, Vol. XX. 8vo. 1861.

Proceedings, Jan. 1863. 8vo.

Condy, Henry B. Esq. (the Author)—Air and Water: their Impurities and Purification. 8vo. 1862.

De la Rue, Warren, Esq. F.R.S. M.R.I. (the Author)—The Total Solar Eclipse of July 18, 1860. (From Phil. Trans. Roy. Soc. for 1862. 4to. 1862.)

Devincenzi, M. G. (the Author)—Cultivation of Cotton in Italy. (L 13) 8vo.

Relazione: Esposizione Internazionale del 1862. (M 7) 4to. 1862.

Dublin Society, Royal—Journal, Nos. 26, 27, 28. 8vo. 1862.

Editors—American Journal of Science, by B. Silliman, &c. for November, 1862. 8vo.

Artizan for December, 1862, and January, 1863. 4to.

Athenæum for December, 1862, and January, 1863. 4to.

Chemical News for December, 1862, and January, 1863. 4to.

Engineer for December, 1862, and January, 1863. fol.

Horological Journal, Nos. 53, 54. 4to.

Journal of Gas-Lighting for December, 1862, and January, 1863. 4to.

Mechanics' Magazine for December, 1862, and January, 1862. 8vo.

Medical Circular for December, 1862, and January, 1863. 8vo.

Practical Mechanics' Journal for December, 1862, and January, 1863. 4to.

St. James's Medley, No. 33. 8vo. 1862.

Technologist for December, 1862, and January, 1863. 8vo.

Franklin Institute of Pennsylvania—Journal, No. 443. 8vo. 1862.

Genève: Société de Physique—Mémoires. Tome XVI. Partie 2. 4to. 1862.

Hogg, John, Esq. (*the Author*)—On some Inscriptions from Cyprus; and on the supposed Scriptural Names of Baalbec. (From Trans. of Roy. Soc. Lit.) 8vo. 1862.

Holland, Sir Henry, Bart. D.C.L. M.D. F.R.S. M.R.I. (*the Author*)—Essays on Scientific and other Subjects. New Edition. 8vo. 1862.

Horticultural Society, Royal—Proceedings, 1862, No. 12. 1863, No. 1. 8vo.

Institut Impérial de France, Académie des Sciences—Mémoires: Tome XXXIII. et Atlas. 4to. 1861.

  Supplément aux Comptes Rendus. Tome II. 4to. 1861.

  Mémoires présentés par divers Savans. Tomes XVI et XVII. 4to. 1852.

Kupffer, M. A. T. (*the Director*)—Annales de l'Observatoire Physique Central de Russie. 1859. 2 vols. 4to. 1862.

Lawrance, R.M. M.D. (*the Author*)—On Localized Galvanism applied to the Treatment of Paralysis, &c. (O 11) 12mo. 1858.

Lloyd, W. Watkyss, Esq. M.R.I. (*the Author*)—On Proportion in Architectural Design. (M 7) 4to. 1863.

Lubbock, John, Esq. F.R.S. M.R.I. (*the Author*)—North American Archæology. (From Nat. Hist. Review, 1863.)

Mailly, M. Ed. (*the Author*)—Essai sur les Institutions Scientifiques de la Grande Bretagne. No. 3. (O 14) 12mo. 1863.

Mechanical Engineers' Institution, Birmingham—Proceedings: July. 8vo. 1862.

Müller, Professor Max (*the Author*)—On Ancient Hindu Astronomy and Chronology. (In Vol. IV. of Rig Veda.) 4to. 1862.

Musgrave, Rev. George M. M.A. (*the Author*)—Ramble through Normandy. 16mo. 1855.

  Pilgrimage into Dauphiné. 2 vols. 16mo. 1857.

  By-Roads and Battle-Fields in Picardy. 8vo. 1861.

Newton, Messrs.—London Journal (New Series) for January, 1863. 8vo.

Petermann, A. Esq. (*the Editor*)—Mittheilungen aus dem Gesammtgebiete der Geographie. Nos. 11, 12. 4to. 1862.

Photographic Society—Journal, Nos. 128, 129. 8vo. 1862.

Prince, C. Leeson, Esq. (*the Author*)—Meteorological Journal. 1862.

Roma, Accademia Pontificia de' Nuovi Lincei—Atti. Anno XIV. Sess. 1, 2. 4to. 1861.

Royal Society of London—Philosophical Transactions:—1861, Parts 2 and 3; 1862, Part 1. 4to. 1862.

  Proceedings, Nos. 51, 52. 8vo. 1862.

Scottish Society of Arts, Royal—Transactions, Vol. VI. Part 2. 8vo. 1862.

Statistical Society—Journal, Vol. XXV. Part 4. 8vo. 1862.

Upsal, Royal Society of Sciences—Nova Acta. Series III. Vól. IV. Fasc. 1. Upsalá Universitets Arsskrift. 1861. 8vo. 1862.

Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Sept. Oct. 1862. 4to.

Vincent, B. Assistant-Secretary and Keeper of the Library, R.I. (*the Editor*)—Haydn's Dictionary of Dates. Eleventh Edition. (Two Copies.) 8vo. 1863.

WEEKLY EVENING MEETING,

Friday, February 6, 1863.

COL. PHILIP JAMES YORKE, F.R.S. in the Chair.

JAMES GLAISHER, Esq. F.R.S.

On Aerial Scientific Research.

[Abstract deferred.]

WEEKLY EVENING MEETING,

Friday, February 13, 1863.

William Robert Grove, Esq. M.A. Q.C. F.R.S. Vice-President, in the Chair.

Edward Frankland, Esq. F.R.S.

On Artificial Illumination.

Ten years ago the speaker gave in this Institution a sketch of the condition of Artificial Illumination. Since that period but little progress had been made towards perfecting those processes of producing artificial light at that time in general use. Nevertheless, the improvements effected in the production and application of the electric light, the increase of our knowledge both of solar and terrestrial light, and especially the discovery of an entirely new illuminating agent, threatening to produce a revolution in lighting almost equal to that which was the result of the invention of gas—rendered it desirable again to review this subject after the lapse of a decade.

In glancing at the improvements effected in the different departments of artificial illumination, those which relate to the Electric Light were first noticed. The electric light is produced by the interruption of an electric current flowing through good conductors; by this interruption the current is made to leap across a space provided in its circuit. The boundaries of this space, in the ordinary electric light, are formed by two portions of gas carbon, and during the passage of the electric current across it, the two pieces of carbon are heated to a most intense degree, and far beyond that produced by any other means at our disposal. The great source of illuminating power was shown to be the ignited ends of these two pieces of gas-carbon, and not the space between them.

Such being the nature of the electric light, the principal improvement which has been effected in it, during the past ten years, consists in the production of the electric current through the intervention of heat and mechanical force, by what is termed magneto-electricity. More than thirty years ago, Mr. Faraday produced a spark from the ordinary permanent magnet. Here, said the speaker (producing a magnet) is the very cradle of this magneto-electric light, and this is the very magnet with which Mr. Faraday operated. This improvement constitutes one of the greatest steps in advance which have been made in the application and production of the electric light. By the combustion of coal a certain amount of mechanical power is obtained, which is applied to the rotation of masses of iron in the neighbourhood of very powerful permanent magnets. In this way, currents of electricity are produced, and these are thrown together, and made to circulate through a system of conductors: in fact, there is no difference, as regards the effect at the carbon-prisms, between the action of this magneto-electric current, and the ordinary electric current produced by the chemical action which takes place in the voltaic battery. But this improved mode of producing the electric force demands less manual labour; the mechanical work being performed by a steam-engine, which causes the rotation of the armatures.

This magneto-electric apparatus, as perfected by Mr. Holmes, has now been in use for upwards of two years in the South Foreland and Dungeness lighthouses, where, as well as in other similar beacons, the production of a light of the greatest intensity is of the greatest importance to the mariner. During this time it has performed its office remarkably well, and without a single instance of failure; thus proving itself well adapted for the purposes of lighthouse illumination.

For domestic light it has not yet been brought into use; its expense, doubtless, at the present moment, being far too great to admit of its being employed in this way: but where a light of great intensity, regardless almost of the question of expense, is required, as in the case of lighthouses, this magneto-electric light can scarcely be too much prized.

The speaker also described the mercurial electric light, but considered it inferior both in brilliancy and steadiness to that procured by the passage of the electric current between carbon terminals.

The discoveries and improvements connected with Gas as an illuminating agent were then considered. It is of great importance that gas, as a light-giving material, should be improved to the utmost possible extent, so as to make it a perfect source of light. Its conveniences are so patent to every one, its use is attended with so few discomforts, and the light is obtained with such facility, and of any desired intensity within certain limits, that there is, perhaps, no source of artificial light capable of such general application. Nevertheless, this is one of the modes of illumination which, having been long previously in use, have not made great progress during the past ten years. The sulphur compounds, which at the commencement of that time were complained of as being present in purified gas, are still there in considerable, if not in undiminished quantity, although there has recently been a process devised by means of which these impurities can be, to a great extent, got rid of. It remains to be seen whether this process be applicable, on a large scale, in the gas manufactory; but, so far as can be judged from experiments made upon a small scale, it is a process which is likely to be very effective. It is the invention of the Rev. Mr. Bowditch, of Wakefield. These sulphur compounds are irremovable in the ordinary process of purification. The gas may be passed in the usual manner over hydrate of lime, or the peroxide of iron; but this operation does not, in the slightest degree, affect the sulphur compounds in question. During the combustion of the gas, however, their sulphur is converted into sulphurous acid, which diffuses itself into the apartment in which the gas is burned, and a great deal of the discomfort of which many complain in the use of gas is due to this cause. Mr. Bowditch discovered that though cold hydrate of lime will not remove these impurities, they are to a great extent got rid of by heating the hydrate of lime to a temperature varying from the boiling point of water up to 400° or 500° Fahr., a temperature of 400° being the most convenient for the development of the effects of his process. The heated hydrate of lime converts the sulphur compounds into sulphuretted hydrogen and carbonic acid, which can then be removed by the ordinary purifying material—cold hydrate of lime. This process has been found by repeated experiments to remove all but about 2 or 3 grains of sulphur per 100 cubic feet of gas, the quantity of sulphur originally contained in the gas varying from 5 or 6 grains up to 20 grains in 100 cubic feet. Heated hydrate of lime was shown to develop sulphuretted hydrogen from the gas supplied to the Institution.

Another recently ascertained fact in connection with gas is the discovery of a new illuminating constituent recently made by M. Berthelot. This is a gaseous body, called Acetylene, which is produced under very peculiar circumstances. Unlike all other hydrocarbons with which we were formerly acquainted, an intense heat is favourable to the production of this body. For instance, it is produced when coke is very intensely ignited in hydrogen gas; and Dr. Odling has recently demonstrated that two of the constituents of coal-gas, light carburetted hydrogen and carbonic oxide, which are useless for lighting purposes, may, by means of strong ignition, be made to form acetylene, and thus become luminiferous agents. It has generally been considered important to preserve a moderate degree of heat in gas-making, in order to prevent the destruction of the luminiferous hydrocarbons; but the discovery of the formation of acetylene, under the circumstances named, will render it necessary to investigate how far the production of this substance can be carried on upon a large scale, and rendered valuable for increasing the illuminating power of gas. The subject is yet in embryo; but it has an important bearing upon the future progress of gas-lighting. Acetylene and olefiant gas contain, in equal volumes, the same amount of carbon, but the former contains only half as mnch hydrogen as the latter; consequently, the illuminating power of acetylene is probably at least double that of olefiant gas.

The compound of acetylene with copper, is a substance not altogether devoid of interest to the gas-manufacturer. When it attains a certain heat, it explodes with considerable violence, and the same effect may be produced by friction. It has been demonstrated recently, that acetylide of copper can be produced by the passage of ordinary coal-gas, containing, as it does, a trace of ammonia, through copper or brass tubes; and explosions which have taken place through cleaning out such tubes, resulting in serious injury to workmen, have been doubtless due to the presence of this substance. It is, of course, obvious that an explosion of this kind, even if slight in itself, may be communicated to explosive mixtures of gas and air (in a gas-holder or gas-meter, for instance), and may thus lead to very disastrous results. An explosion of this kind occurred a few years ago in Lancashire. A large meter had been detached, and brought into the open air; a workman was unscrewing one of the brass connections, when the meter exploded with a loud report. The explosion could not be accounted for, as all the eye-witnesses were positive that no ignited body of any kind was near the meter.

The improvements effected in the production and application of Oils for illuminating purposes were next referred to.

The animal and vegetable oils, which for ages have been employed for this purpose, have received no development of importance during the last ten years. On the other hand, new sources of this class of illuminants have been discovered, which threaten to produce a great revolution in the modes of obtaining artificial light.

One of the most important of the materials manufactured from these sources is paraffin-oil, the production of which from Bog coal has been carried out on an immense scale with great ingenuity and success by Mr. Young, of Bathgate, near Edinburgh. [The speaker here exhibited several lamps fed with this oil.] This new source of light is however already threatened by a formidable rival—native coal oil—which has been distilled by nature herself, and consequently does not require those preliminary processes which oil produced from bituminous coal has to undergo. These discoveries have been made principally in the United States of America, and more especially in Canada. In the latter country alone no less than twenty millions of gallons of this oil have been obtained from wells, several of which are spouting-wells. From these the oil rises, probably from the pressure of gas, to a considerable height above the surface of the ground, so as not to require pumping. The twenty millions of gallons, which represent the annual production of the Canadian wells, may, upon a moderate calculation, be said to furnish, in refined oil alone, illuminating material equal to one hundred and eighty millions of pounds of sperm candles.

The importance of such a vast amount of illuminating material so cheaply obtained can scarcely be overrated in connexion with the question of the production of artificial light. Up to the present time, the refined oil from this crude petroleum (specimens of which were exhibited) has been prevented from coming into effective competition with the original paraffin-oil, owing to the carelessness with which the former has been manufactured. There is a considerable portion of light naphtha left in this oil, which renders it capable of forming explosive mixtures in the lamps wherein it is burned. Both these American oils require to be still further freed from volatile naphtha. They would then form valuable illuminating materials.

The speaker then directed attention to the following tables. The first contains the results of his experiments on the illuminating effect of these oils in connection with that of some other materials used for giving artificial light:—

Illuminating Equivalents, or the Quantities of different Illuminating Materials necessary to Produce the same amount of Light.

Young's Paraffin-oil	1	gallon
American rock-oil, No. 1	1·26	,,
do. No. 2	1·30	,,
Paraffin candles	18·6	lbs.
Sperm do.	22·9	,,
Wax do.	26·4	,,
Stearic do.	27·6	,,
Composite do.	29·5	,,
Tallow	36	,,

From this table was made the following calculation of the comparative cost, from different sources, of the light of twenty spermaceti candles, each burning for ten hours, at the rate of 120 grains per hour:—

	s.	d.
Wax	7	2½
Spermaceti	6	8
Tallow	2	8
Sperm-oil	1	10
Coal-gas	0	4¼
Cannel-gas	0	3
Paraffin	3	10
Paraffin-oil	0	5
Rock-oil	0	6½

Thus, from an economical point of view, the rock-oil and the paraffin-oil approach gas much more closely than any other illuminating agent hitherto invented; while the enormous quantities in which these oils are now being produced cannot fail to make them still lower in price. They may consequently be regarded as very formidable rivals of gas-light.

The following table contains the amount of carbonic acid and heat generated per hour by various illuminating agents, each giving the light of twenty sperm candles:—

	Carbonic acid.	Heat.
Tallow	10·1 cubic feet	100
Spermaceti Wax	8·3 ,,	82
Paraffin	6·7 ,,	66
Coal-gas	5·0 ,,	47
Cannel-gas	4·0 ,,	32
Paraffin-oil Rock-oil	3·0 ,,	29

This table shows to what extent the atmosphere of rooms is deteriorated by these illuminating agents. It shows also that, from this point of view, paraffin and rock-oils stand out as the best sources of light

The chemical and physical laws upon which all modes of artificial illumination depend were then referred to. Every method of artificial illumination depends upon the heating of certain bodies to such a temperature that they become incandescent With gases this temperature is much higher than with liquids or solids. There is only one instance in which the incandescence of vapour is used, and that is the mercurial electric light, already alluded to. In all other cases the incandescence of solid bodies is employed. In the ordinary method of obtaining the electric light, the incandescence of solid prisms of carbon is the source of luminosity. In gas and oil flames, it is the incandescence of little particles of carbon, and in all these cases the light is produced from solid matter. The luminosity of any flame depends, first, upon the number of solid particles which exist in it at any given moment; and, secondly, upon the temperature of the flame. The number of solid particles is dependent upon the nature of the flame itself, whether it be a flame produced by the burning of bodies rich in hydrocarbons, or by the burning of bodies which are poorer in this respect. Such a flame is always affected by the pressure of the atmosphere. The higher the pressure of the air, the greater the number of luminous particles of carbon present at one time in the flame. If, after the barometer has been standing at 30 inches, it falls to 29 inches, the light of all flames is reduced to the extent of about 5 per cent. The temperature, upon which the luminosity of a flame also depends, may be increased by heating both the gas and the air supplied to it for combustion, before they are brought together to be burned.

The speaker exhibited a gas lamp which he had constructed to effect this object. It consisted of an ordinary argand burner, with glass chimney, but furnished with an outer glass cylinder resting upon a solid plate of glass, through the centre of which the tube supplying the gas rose. Thus all the air supplied to the flame was compelled to pass down between the chimney and outer cylinder, becoming thereby strongly heated before it reached the flame, whilst considerable heat was also imparted to the gas before the latter issued from the burner. In this manner a great increase of light, with the same consumption of gas, was obtained.

The following table was exhibited, showing the effect of this hot air gas-burner in reducing the consumption of gas for a given amount of light, and thereby also the impurities and heat which are thrown into the atmosphere in which such a lamp is burned:—

	Rate of consumption per hour.	Illuminating power.
Argand burner supplied with cold air	3·3 cubic feet	13 sperm candles.
	3·7 „	15·5 „
	4·2 „	17 „
Same burner supplied with hot air . .	2·2 „	13 „
	2·6 „	15·5 „
	2·7 „	16·7 „
	3·0 „	19·7 „
	3·3 „	21·7 „

For an equal amount of light, the saving of gas=33 per cent. For an equal consumption of gas, the gain in light=62 per cent.

The temperature necessary to render substances incandescent may be imparted to them in various ways. It may be given directly by mechanical power, as in the "steel mill," formerly used in coal-mines. Usually, however, chemical action is employed, as in gas, candle, and oil-flames; or electricity is used, as in the various forms of electric light.

The conditions necessary for a good and satisfactory artificial light were now examined. In the first place, the light should contain all colours; that is, it should be capable of showing every variety of tint which will be exposed to it. This is the case with the carbon electric light, and that of candle, oil, and gas flames, since the light from these sources contains all the colours of the spectrum. But there are many colours which the mercurial electric light is incapable of showing, since they are absent from its spectrum. It was also shown that all pure colours, except yellow, were perfectly black, when seen by the light of incandescent sodium vapour.

Solar light, although in so many respects superior to artificial light, is defective as regards the showing of colours. There are certain colours which cannot be seen by solar light—for instance, all the colour which can be seen by the sodium flame is quite invisible in daylight. If a pigment could be made of such a yellow colour as to be of exactly the shade of that produced by the sodium flame, it would be absolutely black in solar light. But our pigments are all mixed colours, and no such pigment which thus entirely disappears in the light of the sun is known. But in addition to this tint of the sodium flame, there are hundreds of other tints which are also not present in the solar spectrum, and which are consequently invisible in daylight.

Although solar light is inferior to artificial light in the completeness of its colours, yet, in another respect—in the comparatively small amount of heat which accompanies its rays in proportion to the light itself—it is greatly superior to every sort of artificial light. The great amount of heat in our artificial lights is absolutely useless. It is nearly all intercepted by the humours of the eye before it reaches the retina, and, no doubt, produces that irksomeness which is felt after working in artificial light for any considerable time, and which is not experienced from daylight.

The speaker concluded as follows:—The history of artificial illumination cannot fail to impress upon us the difficulties in the way of the application of scientific discovery to the utilities of life. How long was it after the discovery of the production of gas from coal, before a manufacturer could be found to bring it into actual operation? Thirty years ago, working in his laboratory at Blansko, Reichenbach showed us the process by which we could obtain paraffin and paraffin-oil from bituminous coal; but the discovery remained unheeded for twenty years. More than thirty years ago, Mr. Faraday pointed out a source of the electric light in the permanent magnet; but we are only now beginning to use it for illuminating purposes. The brilliant little spark was long looked upon as a mere scientific curiosity, and is only now beginning to flash across the sea, guiding the mariner safely into harbour, or warning him from approaching a dangerous coast. How long will thermo-electricity have to wait before it receives a similar application? In thermo-electricity we have a direct transformation of the force of heat, which we obtain with such great economy from coal, into an electric current, and this, by further education and development, might be rendered available in the production of the electric light. Hitherto, its application in this direction has been altogether unheeded, and yet, of all sources of the power necessary for the electric light, thermo-electricity evokes this power most directly from coal. In the magneto-electric light we have the great disadvantage, that the heat of burning coal must be first transformed into mechanical power, which is made to rotate the armatures of magnets, and thus produce the necessary electric current. In this transformation of heat into mechanical power there is no less than 9-10ths of the original force in the coal absolutely lost. Hence the advantage which would result from the direct application of heat to the production of the electric current.

The man of science rejoices in the discovery of truth for its own sake. He gives his results freely to the world. It is no part of his duty, it is not his function, to apply those truths to the utilities of life. Success in this direction demands quite different powers of mind. Those who possess these powers, ought also to acquire the necessary knowledge which would enable them, with more facility, to seize upon the discoveries of science, and apply them to the wants of every-day life. This scientific knowledge is the link which, up to the present time, has so sadly failed in the application of science to the manufacturing arts.

[E. F.]

WEEKLY EVENING MEETING.

Friday, February 20, 1863.

Henry Bence Jones, M.D. F.R.S. Honorary Secretary, in the Chair.

Rev. George Williams, B.D.
SENIOR FELLOW OF KING'S COLLEGE, CAMBRIDGE.

On recent Discoveries at Jerusalem.

The Temple Area and the Fortress Antonia.

The chief interest that attaches to the discoveries lately made at Jerusalem by Signor Pierotti, corroborated, as they doubtless will be, in all main points, by the still more recent investigations of the Count de Vogüé and M. Waddington in the course of last year, is derived from the remarkable confirmation which they afford to the received views of the topography and archæology of the Holy City, in the case of those sites which are of greatest importance in connection with its sacred history. I gratefully accept all the facts brought to light by Signor Pierotti, while I differ considerably from his inferences and conclusions. Here I shall state my own views, without entering into controversy.

As it would be impossible to do justice to all these discoveries in the course of a single lecture, I propose to confine my remarks to the site of the Temple and its contiguous fortress, Antonia. The situation of the former appears to be fixed beyond all possibility of doubt by the recent discovery by Signor Pierotti of the complete water system connected with the Hebrew temple, still existing as entire as when it was in daily use during the period of the Jewish commonwealth. The perfect preservation of this complicated system of aqueducts, drains, and reservoirs, is owing to the fact that they are all excavated in the solid rock, and therefore have not been affected by the demolition of the structures above, except so far as they may have become partially blocked up by the accidental falling in of débris of the ruined buildings.

Had history been silent on the subject, yet we should have been forced to conclude, from the account of the various sacrifices connected with the Jewish ritual, especially from the description of the numerous victims offered by Solomon at the Feast of Dedication, that there was a very complete system of sewerage connected with the Temple, introducing a large quantity of water to dilute the blood, which would otherwise have had a tendency to coagulate, and carrying off the blood and offal from the sacred precinct.

This, history tells us, was actually the case. The fullest account which is preserved of these waterworks is contained in the description of the Holy City and of the Temple worship, in a tract of Aristeas, who visited Jerusalem during the reign of Ptolemy Philadelphus, and who describes a vast series of reservoirs beneath the area of the Temple, supplied by a copious spring of living water, and connected together by pipes and conduits extending over a space of five furlongs. There were many openings to these hidden depths from the area above, the secret of which was known only to the ministers of the Temple; and the supply of water was so managed as to flush the whole court, and carry off the blood of the numerous sacrifices. This description is fully confirmed by the Mishna and other Jewish authorities.

This language, which might formerly have appeared exaggerated, is now proved to be literally correct; for those cisterns have been actually explored, and the conduits and drains traversed in all directions by Signor Pierotti; so it is no more matter of conjecture, but of ascertained and positive fact.

It was the happy suggestion of Professor Willis, and a striking example of that marvellous intuition for which he is so remarkable in investigations of this nature, that the hole in the Sacred Rock of the Moslems, under the well-known Dome of their Mosk, and the cave in that rock, now so familiar to all from the frequent descriptions of many travellers, but especially from the drawings of Mr. Catherwood, were the drain and cesspool of the Jewish altar; and that the round hole in the centre of the rocky pavement of that cave was the mouth of the channel by which the blood, poured out at the horns of the altar, flowed off, according to the Mishna, to the valley of the Kidron. That theory of Professor Willis really implied the condition that, if ever the hollow in the rock under that circular stone should be explored, there would be found an aqueduct for bringing in a supply of water on one side, and a drain for carrying off the blood and water on the other side. Now such is really proved to be the case; and Signor Pierotti has actually entered that lower cave by one channel, and quitted it by the other.

The supply of water, which no longer flows in these channels owing to various obstructions, was derived from the celebrated Pools of Solomon on the road to Hebron, south of Bethlehem, and was brought to Jerusalem by an aqueduct which still exists. It crosses the Valley of the Tyropœon by the artificial embankment which joins Mount Sion to the Temple Mount—the *Bridge* of the Jewish historian. It was then received into a well, sunk in the rock immediately in front of the Porch of El-Aksa, from whence it was distributed according to the exigences of the Temple worship; for the supply could be regulated according to the requirements of the season. The channel for the supply of the Temple ran northward from this well, under the wide causeway which leads from the north door of El-Aksa to the south gate of the Dome of the Rock, passes under the stairs opposite the Gate of Prayer, and so through the rock of the raised platform into the lower cave, as already described, which marks the site of the altar of the daily burnt-sacrifice. When this is once ascertained, the whole Temple can be laid out, with the help of the tract Middoth (Measures) in the Mishna; and it is a curious and interesting fact, that when the various parts of the Temple are distributed and adjusted according to these measures, the interval between the western wall of the Holy of Holies and the boundary-wall of the inner Temple, is exactly what it ought to be, supposing the western limit of the inner Temple to correspond with that of the raised platform of the Haram, which, as being cut in the live rock, has probably remained unaltered from Jewish times.

The drain from under the Jewish altar then runs northward for a distance of 120 feet, to a large double cistern, hollowed in the rock of the raised platform of the Haram. The Jewish authorities inform us, that the place where the victims were slaughtered, the hooks to which they were hung for the purpose of being flayed, and the marble tables on which they were dressed, and the parts appropriate for the sacrifice separated and prepared, was to the north of the great altar. Here. therefore, would be the greatest effusion of blood and other mat connected with the slaughter of the beasts; and here, accordingly, were these large receptacles, with an arrangement for a fresh supply of water coming in from the west, the source of which has not yet been fully investigated.

From this point the sewerage took an easterly direction, and ran through a triple rock-hewn tank under the lower area of the Temple, about half way between the raised platform and the eastern wall, where it was further diluted by a fresh supply of water introduced by an aqueduct from the enormous tank outside the northern wall of the Temple Close, known as the traditionary Pool of Bethesda. The drain then passes under the wall of the Haram, and skirting it on the east side, along the narrow ridge now occupied by a Moslem burial-ground, descends steeply to the Fountain of the Virgin, in the valley of the Kidron, where, according to the Mishna, this sewerage from the Temple was disposed of as liquid manure to the market-gardeners.

So much of the water from Solomon's pools as was not required for the use of the Temple, flowed off from the well in front of El-Aksa to an enormous rocky reservoir, called the Royal Pool in the chronicles of the Crusades; from whence it ran by a channel traced by Signor Pierotti, to the same Fountain of the Virgin.

The next point of interest in these recent discoveries, is the secret passage which Herod the Great made, according to Josephus, for the purpose of connecting the fortress of Antonia with the eastern gate of the *inner* Temple—as the present text of the Jewish historian reads. Such a passage has been found by Signor Pierotti, extending from the Golden Gate in a north-westerly direction. But unhappily he has not been able to follow it along its whole length; only one section from the Golden Gate about 130 feet long, and another fragment of about 150 feet in length, being at present practicable.

It is true that this would connect Antonia with the eastern gate of the *outer*, not of the *inner* Temple. But in the first place, it is obvious that if the passage had been designed to communicate with the *inner* Temple, it would have run to the northern, not to the eastern gate, which was much more distant from the fortress; and further, as one object of Herod was to provide for his escape into the country, in case of a sedition in the city, that purpose would not have been answered by securing a hidden access only to the gate of the inner Temple. When then, it is considered that the change of a single letter would obviate these difficulties, and place the passage precisely where it is found, it is perhaps not taking too great a liberty with the text to propose to read *τοῦ ἔξωθεν ἱεροῦ* (the outer Temple) in the passage in question, instead of *τοῦ ἔσωθεν ἱεροῦ* (the inner Temple) as the text now stands.

The course of Herod's passage is of great importance for determining the position both of the eastern gate and of the fortress Antonia. It has been much disputed, whether that fortress stood entirely without the present area of the Haram, or entirely within it; or partly within, partly without. Light may be thrown on this question by an angle of massive masonry, which has been found embedded in the rock towards the north-west corner of the great court of the Mosk, between the raised platform and that corner which presents along its north side a wall of solid rock rising to a height of from twenty to twenty-five feet. Indeed, the whole area in this quarter bears marks of the rock having been worked down to its present level by artificial means; and corroborates the account given by Josephus of the operations of the Jews under Simon the Maccabee, after having driven the Macedonian garrison out of the castle built on the Temple-mount by Antiochus Epiphanes. He tells us that they not only demolished the castle, but rooted up the very rock on which it was built, in order that they might never for the future be subjected to like annoyance. It was a great work, and occupied them three years and six months, although they worked at it incessantly night and day.

It is not likely, then, that this angle of solid masonry can have belonged to a building, not only destroyed to the foundation, but the very site of which was removed. It was more probably connected with the fortress Antonia of later times; and, if so, may serve to explain a perplexing passage of Josephus, who, in speaking of the portents which preceded the destruction of Jerusalem, says that the Jews, by the destruction of Antonia, had made the Temple quadrangular; while it was written in their oracles that the city should be taken when their Temple became quadrangular. It is vain to inquire to what oracle he refers; but it is obvious to remark that Antonia was not demolished by the Jews, for there is constant reference to it during the siege of Titus. Josephus can only refer to the destruction of some part of the buildings of Antonia contiguous to the Temple, and projecting into the area, the demolition of which made the enclosure quadrangular. The massive masonry lately discovered probably marks the south-east angle of this projection.

That the greater part of the fortress Antonia stood without the Temple Close seems to be proved by another important work which has lately been brought to light.

This is a subterranean passage of noble proportions, partly cut in rock, and partly constructed of very solid masonry, which joins the Haram enclosure near the north-west angle, just east of the minaret, at a depth of about twenty feet below the surface of the rocky pavement of the court, or more than forty feet below the upper surface of the wall of rock, which, as has been already stated, bounds the Haram in this quarter. The direction of this stupendous gallery is northward, bearing slightly to the west. It extends in length 224 feet, passing under the Via Dolorosa. It is 22 feet wide, 29 feet high; covered in at the top with long slabs of stone. There is a door in the side wall, 17 feet high and 9 feet wide, blocked up with solid masonry; and high up in the side walls a row of small openings, as for windows, which seem to be of later date than the gallery itself. Two narrower passages open out of the main vault, one running east, the other west. At the south end of the passage, where it joins the Haram enclosure, is an ancient door, now blocked up; but Signor Pierotti could discover no corresponding door in the rocky wall or pavement above, by which the vault might have had egress to the Temple Close. It is, therefore, very probably the entrance to Herod's secret passage, leading to the eastern gate already noticed, the direction of which, as far as it can be determined by the parts already explored, is towards this doorway.

The great gallery itself must certainly have belonged to the fortress Antonia, or, perhaps, rather to its predecessor, the Baris, or castle of the Asmonean princes, as it answers very closely to the description of the dark subterranean passage which Josephus mentions as the scene of the murder of Antigonus by the guards of his brother Aristobulus, under the tragic circumstances detailed by the historian. This passage was called Strato's Tower, and was so closely connected with the Baris that the sounds from the vault reached the ears of the high-priest, Aristobulus, who was lying ill in the castle. It was doubtless a covered way designed to connect one part of the fortress with another, for greater security in the case of siege. A little beyond the northern extremity of this passage, but near the surface of the ground, Signor Pierotti accidentally tapped what appeared to be a tank of rotten water, but it continued to flow on, and has never ceased, thus proving itself to be an aqueduct, probably part of that great work of King Hezekiah, recorded in the 2nd Book of Chronicles xxxii. 3, 4, 30, and referred to in his eulogy in the Book of Ecclesiasticus, xlviii. 17.

Another remarkable confirmation of the hypothesis that the fortress Antonia occupied the site determined by the subway just noticed, is found in the situation of the Roman arch, commonly known as "the Arch of the Ecce Homo," which spans the Via Dolorosa about 90 feet west of the point where that street passes over the subterranean gallery. It had long been doubted whether the arch in question was a Roman arch. That doubt has now been removed by the accidental discovery of the north side portal of the Gateway. It had been covered for centuries by débris, and was accidentally brought to light by a landslip, occasioned by an excavation being made in the neighbourhood, for the foundation of buildings connected with the establishment of the "Filles de Sion." This portal is unquestionably of Roman workmanship, as is also the larger arch; and there was no doubt a corresponding portal on the south side, which may still be discovered. Thus the gateway would resemble those ancient arches which are still found in Rome, imitations of which were not unfrequent in the provinces—which also furnished models for Temple Bar and the Marble Arch!

Such a gateway in this situation could be nothing else than the communication between the city and the fortress Antonia, or the successor of that fortress, which may possibly have been erected when Jerusalem was restored by Hadrian, under the name of Ælia Capitolina.

From this it results that the house of the Turkish Pasha occupies the site of the official residence of the Roman Governor, and that the barracks of the Turkish troops are in the same position as that occupied by the Roman garrison at the era of the Gospel narrative. Nothing changes in the East.

[G. W.]

WEEKLY EVENING MEETING,

Friday, February 27, 1863.

The Rev. JOHN BARLOW, M.A. F.R.S. Vice-President, in the Chair.

JOHN LUBBOCK, Esq. F.R.S.

On the Ancient Lake-Habitations of Switzerland.

AFTER explaining the circumstances which led to the discovery by Dr. Keller, of the Pfahlbauten,* or Lake-habitations of Switzerland; and after referring to the account given by Herodotus, of the Pæonians, who dwelt on platforms over Lake Prasias, Mr. Lubbock proceeded to state that the Lake-villages of Switzerland might be divided into three classes:—Firstly, those in which all the instruments are made of stone and bone, and which are therefore said to belong to the Stone age; secondly, those in which objects made of bronze also occur, and which therefore are said to belong to the Bronze age; and thirdly, those in which implements of iron have been discovered. Of the first class at least fifty Lake-villages have been described; the second class is even more numerous; but of the third, only very few are known.

On the larger lakes several of these curious villages have been discovered: thus, on the Lake of Bienne twenty are known; on the Lake of Geneva, about twenty-four; on the Lake of Constance, more than thirty; and on that of Neufchatel, as many as forty-six.

As a type of the Pfahlbauten belonging to the Stone age, Mr. Lubbock took the one at Wauwyl, which is a small station on a flat plain, on the railway from Sofingen, in the canton of Lucerne. Originally a lake, the growth of peat turned it into a marsh, which has now been drained.

Here and there a few piles may be seen, projecting two or three feet above the general surface; and on examining the peat at these spots, and comparing them with its structure elsewhere, it appears that when the plain was under water, the natives had made small artificial islands, by heaping together leaves, branches of trees, and mud, and enclosing them by, as it were, walls of piles to prevent them from being washed away.

---

* For further details, the Memoirs by Dr. Keller and Prof. Troyon, and the article in the 'Natural History Review' for January, 1862, may be consulted; also M. Morlot's admirable 'Leçon d'Ouverture d'un Cours sur la haute Antiquité.'

Mr. Lubbock had the advantage of visiting this interesting spot with Col. Suter, MM. Suter, Morlot, and Fickart, on which occasion several ancient implements made of stone and bone were obtained, besides numerous fragments of pottery, and many bones of animals which had been used as food.

The total list of objects hitherto found at Wauwyl is as follows :—

Stone axes, principally of serpentine	28	
Small flint arrowheads	22	
Flint flakes	136	
Corncrushers	13	Not all collected.
Rude stones used as hammers, common (say)	20	
Whetstones	18	
Slingstones	43	
In all about	274	articles of stone.

The implements of bone are less numerous; those found at Wauwyl, as elsewhere, appear to fall into four principal divisions.

Pointed bones, or awls	31
Chisel-like bones	46
Ribs split and pointed at one end	4
Axe-handles	2

Besides which are a few teeth, artificially perforated; and one or two harpoonlike instruments, making altogether nearly a hundred articles made of bone.

There are also a few objects made of *wood;* but these, even if originally numerous, would be difficult to distinguish from the surrounding peat, especially as it contains so many branches, and they would also be very difficult to extract entire. Perhaps, therefore, implements of wood may have been much more varied and common than the collections would appear to indicate.

It is impossible to give any numerical statistics about the pottery on account of the fragmentary state in which it is found. It is however very rude and coarse, containing grains of quartz; and there is no evidence that the potter's wheel was in use.

We know nothing as yet about the manner in which the ancient inhabitants of Wauwyl were clothed. In some of the other settlements, however, which belong also to what is called the Stone age, although possibly to a later portion of it, as for instance in the Pfahlbauten at Robenhausen, on Lake Pfeffikon, and Wangen, on Lake Constance, pieces of rude stuff made of flax and straw have been found.

Similarly, Robenhausen and Wangen have supplied us with numerous specimens of wheat and barley, both as single grains and in the ear, with pieces of apples and pears, and even with a few cakes of bread or biscuit.

The animal remains from Wauwyl have been examined by Professor Rutimeyer, of Basle, and include nearly thirty species, all belonging to xisting species, excepting the Bos primigenius; and even this is per-aps represented by some of the races of our domestic oxen.

The commonest species are the red deer, the domestic ox, and the marsh boar, a variety which is supposed by Professor Rutimeyer to be distinct from the common wild boar of Europe, and which he considers o have been wild at Wauwyl, though it seems to have been domesticated by the inhabitants of the later Pile-buildings. Human bones are very rare. Indeed, in the very last memoir which has appeared on the sub-ect, M. Desor states that no single human skeleton has yet been obtained from any one of the numerous Pfahlbauten of the Stone age.

The examination of the tumuli does not seem as yet to have thrown much light upon this part of the question. So far indeed as Denmark s concerned, the case is very different; many skeletons have there been found in the great chambered tumuli, belonging to the Stone age. The skulls are small and round, altogether resembling those of the Lapps, and very different from those now most common in Europe, as well as from those which are found in interments of the Iron age.

Whether the same was the case in Switzerland and Europe generally, still remains to be proved; many archæologists incline more or less strongly to the opinion, that at the Stone age our continent was inhabited by a race of men akin to the modern Laplanders, who have n the south been replaced by a superior and more civilized race. Dr. Keller, however, appears to consider that the Pfahlbauten show a gradual improvement, and not any such sudden changes.

There are also in the Lake-habitations of the Stone age some traces of commerce, or at least of barter. The flint, of which the flakes and arrowheads were formed, must have come from a distance, and the best pieces in all probability were imported from France. Perhaps, however, this was not the result of any commerce, properly so called, but visits may have been made to the French quarries, just as Catlin tells us that the American tribes, from far and near, visited the red pipestone quarry of Côteau des Prairies.

Some pieces of Mediterranean coral have been found at Concise, and of Baltic amber at Meilen. But as both these settlements appear to have belonged to the transitional period, between the stone and the bronze, we must not lay too much stress on them.

But the most important fact of this nature is the presence of axes made from nephrite. This rock is not known to occur in the Alps, or indeed in Switzerland, and the Swiss naturalists infer that it must have been introduced from the East. Even if, however, this should eventually turn out to be correct, it would not be a conclusive proof of commerce properly so called, as the nephrite might have passed from hand to hand and from tribe to tribe by a sort of barter. Other facts of a similar tendency are on record. Thus Messrs. Squier and Davis tell us (p. 306) that in the tumuli of the Mississippi valley we find "side by side, in the same mounds, native copper from Lake Superior, mica from the Alleghanies, shells from the Gulf, and obsidian (perhaps porphyry) from Mexico." Good representations of the seacow, or manatee, are found a thousand miles from the shores inhabited by that animal, and shells of the large tropical Pyrula Perversa are found in the tumuli, round the great lakes, two thousand miles from home.

The Pfahlbauten at the Pont de Thiele, between the Lakes of Bienne and Neufchatel, those at Lake Moosseedorf and at Lake Pfeffikon, in fact most of those situated on small lakes or lagoons, are more or less grown over with peat. On the contrary, in the large lakes no peat grows. At the entrance of the rivers, indeed, much mud is of course accumulated; the Lake of Geneva, for instance, once no doubt extended for a considerable distance up the valley of the Rhone. But the gravel and mud brought down by that river are, as every one knows, soon deposited, and the water of the lake is elsewhere beautifully clear and pure.

The lake itself is very deep, in parts as much as 980 feet, and the banks are generally steep; but round the margin there is in most places a fringe of shallow water, due probably to the erosive action of the waves, and known to the fishermen as the "blancfond," because the lake is there of a pale greyish hue when contrasted with the bright blue of the central, deeper water.

It is on this "blancfond," and at depths of sometimes as much as fifteen feet, that the Pfahlbauten were generally constructed.

All that can now be seen are the tops of the piles, which project but little above the bottom of the lakes, their upper parts having been worn away by the action of the water.

They are but seen in winter, when the water is both lower and clearer; but even in summer they are quite visible, if the water is still, and may even be seen from the deck of a steamboat. Mr. Lubbock had visited several of the settlements on the Lake of Geneva, and had himself obtained bits of pottery, &c , from them.

Dwellings thus built over the water would not only protect their inhabitants from the attacks of wild beasts, but would also serve as fortifications; still, though it is evident that the security thus given would amply compensate for much extra labour, it still remains difficult to understand in what manner the piles were driven into it.

In many cases indeed settlements of the Stone age are characterized by what are called "steinbergs," that is to say, artificial heaps of stones, &c., evidently brought by the natives to serve as a support to the piles. In fact, they found it easier to raise the bottom round the piles, than to drive the piles into the bottom.

Turning then to the Pfahlbauten belonging to the Bronze age, Mr. Lubbock described the one at Nidau on the Lake of Bienne, whence a very large and interesting collection has been obtained by Col. Schwab. As a considerable number of objects made of stone have been found here, it is possible that this place was inhabited during the Stone age. It is, however, characterized by the great number of weapons, instruments, and ornaments made of bronze, such as axes, lances, sickles, fish-hooks, bracelets, hairpins, earrings, &c., which are altogether nearly 2000 in number.

These objects were all cast, and the skill displayed in their manufacture, as well as the beauty of their forms and ornamentation, shows a considerable development of art.

The discovery of a bar of tin at Estavayer, and at Morges of a mould for casting celts, proved that some at least of these objects were made in Switzerland, while evidence of a similar nature shows that other countries in Europe, as, for instance, Denmark, England, and Ireland, had also their own foundries.

The similarity of form and ornamentation appears to indicate some communication between different parts of Europe; thus, one of the swords found in Switzerland is almost exactly like a specimen discovered in Denmark. But as Cornwall and Saxony are the only known European sources of tin, the mere presence of bronze is in itself a sufficient evidence not only of metallurgical skill, but also of commerce.

With this immense number of objects in bronze discovered at Nidau, three articles of iron have been discovered. This is not sufficient evidence that the village was occupied during the Iron age. Indeed, the pile-dwellings seem at this period to have greatly diminished, and to have been succeeded by dwellings built on land.

They were not, however, altogether abandoned. The most remarkable lake-dwelling of the Iron age, is that at Téne, in the Lake of Neufchatel, whence many objects in iron have been obtained. The most characteristic are large swords, which are in form and ornamentation entirely different both from those of the Bronze age, and from those used by the Romans.

Here we meet also with baked pottery, of that kind generally known as Roman. Professor Desor, however, considers that both the Romans and the tribes living north of the Alps obtained a knowledge of this art at a very early period, and perhaps from the Etruscans, by whom it was certainly brought to great perfection.

Swords, and other objects like those of the Téne, have been found in a field of battle at a place called the Tiefenau, near Berne, with Gaulish coins. We shall not, therefore, probably be far wrong if we consider that the Téne was a village of the Helvetians, occupied at a period before, but probably not many hundred years before, the great irruption of the Romans into Northern Europe.

Mr. Lubbock then referred to the statement by Hesiod, that there was a time when men worked in bronze, and were ignorant of iron; and to the still more valuable evidence of Homer, who, though acquainted with the use of iron, represented bronze as the common material of arms, instruments, and vessels of various sorts. Though confirmed by the discoveries of Sir R. Colt Hoare, these statements were, however, regarded by many archæologists as poetical myths; and though the scientific classification proposed by the Scandinavian archæologists was gradually gaining ground, it could not be said to be universally adopted.

It is scarcely necessary to observe that these three ages are to be regarded as states of civilization rather than as actual chronological horizons. Western Europe seems to have passed from an age of stone to one of bronze; many nations have (thanks to commerce) risen at once from stone to iron. Again, while the inhabitants of Southern Europe were already acquainted with the use of iron 3000 years ago, at the time of the discovery of America the Mexicans were in an age of bronze, the Northern American Indians in one of copper, while many savage tribes are only in the Stone age even now.

Moreover, it is not to be supposed that stone instruments were altogether abandoned as soon as metal was introduced. For some purposes stone was as good as bronze, or even iron. In religious ceremonies, also, many nations appear to have had a prejudice against the introduction of a new substance. Thus the Egyptians used stone knives in opening bodies which were to be embalmed. The Jews seem to have performed the act of circumcision in the same manner; as we read in Exodus, that Zipporah, the wife of Moses, took a sharp stone for that purpose. The Mexicans, again, are stated to have used obsidian knives in the sacrifices to their idols.

No doubt, also, metal was at first very precious, and was more or less confined to the rich. There is also plenty of evidence derived from the tumuli of the coexistence of stone and bronze implements.

Again, there must have been a period of transition between the Bronze and Iron ages. Soon, however, it would be found that for certain purposes iron had an overwhelming advantage over bronze. Thus when the two metals are found together, all cutting edges, all swords, knives, &c., are formed of iron, while ornaments are made of bronze. So great, indeed, is the advantage of iron as a weapon that we have but little evidence of the two metals having been used simultaneously for this purpose.

As long, however, as these conclusions rested on the evidence derived from tumuli, many objections might be raised to them

Much more satisfactory is that obtained from the kjökkenmöddings of Denmark. These dust-heaps of ancient times, though they teem with flint implements, have not yet yielded any trace of metals, and it is even questionable whether the more skilfully made stone implements are found in them.

They tell, therefore, only one part of the story; while the Pfahlbauten of Switzerland, which are, in fact, subaqueous kjökkenmöddings, illustrate not only the later Stone age, but also that of Bronze, and, though but partially, that of Iron.

Being strongly persuaded that the value of the evidence derived from the Swiss lakes was much enhanced by the great number of objects which had been found, Mr. Lubbock had taken every opportunity of counting the axes, &c., obtained at each locality. In the following table, he has brought together the results, so far at least as regard six of the Pfahlbauten.

—	Stone.					Pottery.		Bone.														
	Axes.	Flakes, &c.	Whetstones.	Cornerushers.	Total.	Jarrings.	Spindle Whorls.	Axe-handles.	Awls, &c.	Totals.	Grand Total.	Axes.	Knives.	Lances.	Sickles.	Pins.	Rings.	Earrings.	Bracelets.	Fishhooks.	Sundries.	Total.
Wangen .	1100	260	100	150	1610	..	100	..	350	350	2060	..	..	..	..	..	..	..	..	..	..	..
Pont de Thiele	17	97	20	1?	135	..	..	22	95	17	252	..	..	..	..	..	..	..	..	..	..	..
Moosseedorf .	101	639	64	4	808	..	1?	16	494	510	1319	..	..	..	..	..	..	..	..	..	..	..
Wauwyl .	22	237	Not collected.	15	274	..	1?	2	86	88	363	..	..	..	..	..	..	..	..	..	..	..
Morges .	0	?	?	Very many.	..	Some	Some	?	?	..	?	50	20	11	11	57	14	..	37	10	Some	210
Nidau . .	33	?	?	335	368	Many	179	..	55	55	?	23	97	24	18	600	318	226	40	126	10	1482

He does not give this table as strictly correct, the smaller numbers indeed, are, he believes, accurate, but the larger ones might doubtless be increased. For instance, in several places the simple flint-flakes, heavy whetstones, and irregular hammers were not all collected; again, in many cases no account had been kept of common objects which had been given away. For these and other reasons, the table, striking as it is, is less so than a more accurate one would have been.

Again, it must be remembered that Moosseedorf and Nidau are within fifteen miles of one another, and that the Pont de Thiele and Nidau are on the borders of the same lake.

But it is not only in the presence or absence of bronze that the Pfahlbauten differ from one another; there are many other indications of progress. We cannot expect to find much evidence of this in the implements of bone or stone, because they were gradually replaced by bronze; but, as has already been mentioned, the better forms of stone axe, and those which are perforated, are very rare, or altogether absent in the stone age, none having been found at the Pont de Thiele, at Moosseedorf, or at Wauwyl, and only two at Wangen.

Again, it is not only by the mere presence of bronze, but by the beauty and variety of the articles made out of it, that we are so much struck. In a collection of articles made at any of the stone age settlements, one cannot fail to remark the uniformity which prevails. The wants of the artificers seem to have been few and simple. In the Bronze age all this is altered. We find not only, as before, axes, arrows, and knives, but in addition swords, lances, sickles, earrings, bracelets, pins, rings, and a variety of other articles. Moreover, it is a very remarkable fact, especially when we consider the great, I might say the immense number of bronze celts which are found, that scarcely two of them have been cast in the same mould.

The pottery again tells the same tale. There is no evidence that the potter's wheel was known to the men of the Stone age, while there is proof that it was in use in the Bronze age. Again, the materials of which the Stone age pottery is composed are very rough, and contain large grains of quartz, while that of the Bronze age is much more carefully prepared. The ornaments of the two periods show also a great contrast. In the Stone age they consist of impressions made by the nail, or the finger, and sometimes by a cord twisted round the soft clay. The lines are all straight, or if curved are very irregular, and badly drawn. In the Bronze age all the patterns present in the Stone age are continued, but in addition we find circles and spirals; while imitations of animals and plants are characteristic of the Iron age.

Here again is a table abstracted from a larger one given by Professor Rutimeyer :—1, represents a single individual; 2, several individuals; 3, denotes the species which are common; 4, those which are very common; and 5, those which are present in great numbers.

A glance at the table will show that wild animals preponderate in the Stone age of Pfahlbauten at Moosseedorf and Wauwyl, tame ones at the Bronze age settlement of Nidau.

	Wauwyl.	Moossee-dorf.	Nidau.
WILD ANIMALS.			
The Brown Bear	..	2	..
Badger	2	2	..
Marten	3	2	..
Pine Marten	3	2	..
Polecat	2	2	..
Wolf	1	..	..
Fox	3	3	..
Wild Cat	2	2	..
Beaver	2	3	..
Elk	1	1	1
Urus	..	1	..
Bison	1	..	..
Stag	5	5	5
Roe Deer	2	4	..
	—	—	—
Wild Boar*	2	2	..
Marsh Boar	5	5	2
	—	—	—
DOMESTIC ANIMALS.			
Domestic Boar	? 1	..	3
Horse	2	? 1	3
Ox	5	5	5
Goat	2	2	3
Sheep	1	2	4
Dog	2	2	3
	—	—	—
	15	14	21

Thus, then, we see that the distinction between the ages of stone and bronze is by no means confined to the mere presence of metal. Some may consider that the evidence is not yet sufficient to justify any conclusion. Still the nature and execution of the ornaments—the manufacture of the pottery, the presence of the potter's wheel, the greater variety of requirements as evidenced by the greater variety of implements, the indications of more advanced husbandry, the diminution of wild animals and the increase of tame ones—all indicate a higher civilization for the inhabitants of Morges and Nidau, than for those of Moosseedorf and Wauwyl.

The speaker then pointed out, in a few words, the distinctive features of the earlier stone, or drift period. The stone hatchets of this age are invariably left rough, not one out of several thousands which have now been discovered showing any trace of being polished; while those of the second stone period, that to which the Swiss Lake-habitations belong, are as invariably ground. Secondly, the greater antiquity of the drift hatchets is indicated by the position in which they are found; and, thirdly, by the remains of extinct mammalia, such as the mammoth and the woolly-haired rhinoceros, with which they are found.

---

* At first wild, subsequently domesticated.

Thus then we can break up the history of the human race in Europe into four more or less well-marked periods. First, the Drift or Mammoth period; secondly, the later Stone age, to which the Danish Kjökkenmöddings and some of the Swiss Pfahlbauten belong; thirdly, the Bronze age; and fourthly, the Iron age. These four ages will doubtless ere long be again themselves subdivided. Already we may distinguish between a first and a second Iron age; and the Kjökkenmöddings certainly indicate a less advanced civilization than that represented by the Pfahlbauten. This, however, may possibly be accounted for by their geographical position.

There are two cases in which, by comparing the changes which had taken place since the Roman period with those which have occurred since the later Stone age, an approximate date (of from 5000 to 7000 years) has been obtained for the latter. In both these cases the speaker, having been over the ground, could find no flaw in the argument. Such calculations are, however, very uncertain; but if they are confirmed by similar ones made elsewhere, they may eventually lead us to something like a correct chronology.

Mr. Lubbock then concluded as follows:—

"History, indeed, will not help us in our difficulty. The record of a nation's life could not be written until the discovery of letters, themselves one of the most marvellous products of human genius. No trace of them has yet been discovered in the Bronze age; but even assuming, which is not impossible, that writing was then discovered, still this carries us back but a single step, and it is evidently as impossible for a nation to record its own origin and the commencement of its civilization, as it would be for any of us to describe from recollection his own birth and infancy.

"Have we, then, no alternative but to give up the past as hopeless? Is Stonehenge, for instance, never to be anything more to us than an object of ignorant admiration, and is it destined eventually, as it would then perhaps deserve, to be swallowed up by the advancing wave of cultivation? Must we, in the eloquent words of Palgrave, 'Give it up, that speechless past; whether fact or chronology, doctrine or mythology; whether in Europe, Asia, Africa, or America; at Thebes or Palenque, on Lycian shore or Salisbury Plain: lost is lost; gone is gone for ever.'

"Surely this is not so. If, as is becoming more and more probable, the law of causation has held good throughout the history of our world, if nature has remained the same, and the present has always been the natural consequence of the past, then it follows that the past has already written its own history on the present, and the interpretation of the record is a question not of possibility, but of time and perseverance.

"But for the present, we must content ourselves with much humbler results. It is much if the clouds of ignorance are in places clearing away; if from the summit which we occupy we can catch occasional glimpses of the distant past far away beneath our feet.

"So far as these Lake-habitations are concerned, and so far as one short hour would permit, I have endeavoured to give you a faithful account of the discoveries already made, and in doing so have confined myself almost entirely to a simple statement of facts; fearing, lest perhaps imagination, tempted by opportunity, might lead us away from truth. For imagination is a bad master, though a good servant; and yet it is almost as necessary to progress in science and the arts as heat is to life.

"From the stamped bricks of Assyria to the modern printing-press seems but a step; and yet mankind hovered on the brink of discovery for more than 3000 years. So again the piles in the Swiss lakes had long been known, objects of antiquity had even been found among them; yet these were in themselves but barren observations, and have might so remained until now, if the genius of Dr. Keller had not supplied the spark which kindled the dead facts into a living science.

"And yet science is considered by many, perhaps by most of us, as hard, dry, and unpoetical. If the absolute necessity of teaching in our schools some few of the discoveries made in the last 1800 years, is day by day more generally recognized, still it is rather regarded as an evil, than welcomed as a blessing, from the fear lest, in developing the memory, we might tend perhaps to cramp the imagination. Yet science is not only truer, but more sublime than mythology; grander than the disreputable deities of the Greeks, or the old fairy tales of Europe.

"Poets have invented no monsters more wonderful than those which geology has revealed to us. The laws of nature are more powerful and more subtle than any of the genii in the 'Arabian Nights'; and the philosopher who can place himself in harmony with nature, and avail himself of the opportunities by which he is surrounded, need envy neither Merlin his magic, nor Aladdin his lamp.

"Can anything be more magnificent than the last triumph of chemistry, when, not content with the conquest of this world, she soars into the heavens, and by means of his own light, analyzes the sun himself? Or turning once more finally, and but for a moment, to our immediate subject, surely his imagination must be dead indeed who feels no emotion at the spectacle of an ancient and long-forgotten people, after slumbering for centuries in the grave of oblivion, rising thus, as it were, to take once more that place which properly belongs to it in the history of the human race."

[I trust that I may be permitted here to acknowledge the great courtesy which I received from Dr. Keller, Prof. Desor, Col. Schwab, MM. Forel, Ullmann, and Rochat, and indeed from all the Swiss archæologists. Col. Suter and M. Gilliéron also most kindly gave me an opportunity of examining for myself the Lake-dwellings at Wauwyl and the Pont de Thiele, which they have respectively so well studied. But to M. Morlot my thanks are chiefly due, for having devoted to me a month of his valuable time, and for other acts of kindness too numerous to be specially mentioned.]

[J. L.]

GENERAL MONTHLY MEETING,

Monday, March 2, 1863.

WILLIAM POLE, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

Edward Atkinson, Esq.
The Rev. Henry Blunt,
Col. Craven Hildesley Dickens,
Frederick William Gingell, Esq.
Ernest Hart, Esq.
William Hartree, Esq.
John Hogg, Esq. M.A. F.R.S.
William Wood Humphry, Esq.
William Edward Kilburn, Esq.
Henry Lainson, Esq.
Thomas Leckie, M.D.
James Lees, Esq.
William M'Keand, Esq.
Abraham Pope, Esq.
John Rivington, Esq.
John Rutherford Russell, M.D.
John Benjamin Smith, Esq. M.P.
George S. Trower Esq.

were *elected* Members of the Royal Institution.

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

Secretary of State for India—Rig-Veda Sanhitá: the Sacred Hymns of the Brahmans. Edited by Max Müller. Vol. IV. 4to. 1862.

Geological Survey (through Sir R. I. Murchison)—Mineral Statistics. 1860–61. Memoirs. Six Parts. 1859-62. 8vo.

French Government (through M.G. Rouland, Minister of Public Instruction)—Documents Inédits sur l'Histoire de France:—

- Le Mistère du Siége d'Orléans. Ed. F. Guessard et E. D. Certain. 4to. 1862.
- Mémoires de N. J. Foucault. Ed. F. Baudry. 4to. 1862.
- Négociations de la France avec la Toscane. Ed. A. Desjardins. Tome II. 4to. 1861.
- Journal d'Olivier Lefevre D'Ormesson. Ed. M. Cheruel. Tome II. (1661-72.) 4to. 1861.
- Lettres, &c. du Cardinal de Richelieu. Ed. M. Avenel. Tome IV. 4to. 1861.
- Monographie de la Cathédrale de Chartres. Atlas: 7e Livraison. 4to. 1861.

American Philosophical Society—Proceedings, No. 68. 8vo. 1862.
Asiatic Society of Bengal—Journal, No. 286. 8vo. 1862.
Astronomical Society, Royal—Monthly Notices, Jan. 1863. 8vo.
Best, Hon. and Rev. S. M.R.I.—Papers read on the Ninth Anniversary of the Southern Counties Adult Education Society. (K 89) 8vo. 1862.
British Meteorological Society—Report for 1861. 8vo.
Proceedings, 1862. Nos. 1, 2, 3, 4. 8vo.
Chemical Society—Journal, 1863. No. 1. 8vo.
Editors—Artizan for February, 1863. 4to.
Athenæum for February, 1863. 4to.
Chemical News for February, 1863. 4to.
Engineer for February, 1863. fol.
Journal of Gas-Lighting for February, 1863. 4to.
Mechanics' Magazine for February, 1863. 8vo.
Medical Circular for February, 1863. 8vo.
Practical Mechanics' Journal for February, 1863. 4to.
Technologist for February, 1863. 8vo.
Franklin Institute of Pennsylvania—Journal, No. 445. 8vo. 1863.
Geographical Society, Royal—Proceedings, Vol. VII. No. 1. 8vo. 1863.
Geological Society—Quarterly Journal, No. 73. 8vo. 1863.
Gordon, Alexander, Esq. (*the Author*)—On Lighthouses, Lightships, Buoys, and Beacons. (L 13) 8vo. 1863.
Horticultural Society, Royal—Proceedings, 1863. No. 2. 8vo.
Jablonowskische Gesellschaft, Leipzig—Preisschriften. XI. 4to. 1863.
Newton, Messrs.—London Journal (New Series) for February, 1863. 8vo.
Petermann, A. Esq. (*the Editor*)—Mittheilungen aus dem Gesammtgebiete der Geographie. No. 1. 4to. 1863.
Photographic Society—Journal, No. 130. 8vo. 1863.
Royal Society of London—Proceedings, No. 53. 8vo. 1862.
Silliman, Professor—American Journal of Science, &c. for January 1863. 8vo.
Tyndall, Professor J. F.R.S. M.R.I. (*the Author*)—Heat considered as a mode of Motion: being a Course of Twelve Lectures, delivered at the Royal Institution in 1862. 16to. 1863.
United Service Institution, Royal—Journal, No. 24. 8vo. 1862.
Walford, W. S. Esq. M.R.I.—La Manere de Tenere Parlement (in French.) Ed. by T. D. Hardy. [Bound with "Modus tenendi Parliamentum."] 8vo. 1862.

WEEKLY EVENING MEETING,

Friday, March 6, 1863.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

William Allen Miller, M.D. Treasurer R.S.

On the Photographic Transparency of Bodies, and on the Photographic Spectra of the Elementary Bodies.

After a few preliminary remarks upon the triple nature of the force, *calorific*, *luminous*, and *chemical*, associated together in the radiation which emanates from luminous sources, the speaker stated his intention of limiting himself in great measure to some recent investigations upon the chemical rays.*

It is well known that bodies which are transparent to light are not equally so to radiant heat. Glass, for example, which to the eye is perfectly transparent and limpid, arrests a large portion of the rays of heat emitted by bodies which are not sufficiently hot to become luminous. Pure rock-salt, on the other hand, transmits rays of both light and heat from all sources freely. In like manner, in the case of rays which produce chemical action, corresponding effects have been observed; glass absorbing many of the chemical rays, whilst quartz transmits such rays freely.

The chemical rays emitted by luminous objects vary greatly both in quantity and in quality, some sources of light emitting rays of much higher refrangibility than others. Thus, the flame of ordinary coal-gas burned in admixture with air, so as to produce the blue light of a smokeless gas flame, gives out scarcely any rays capable of affecting an ordinary photographic plate; whilst the same amount of gas, burned in the ordinary manner for illumination, emits a very decided though limited amount of rays capable of producing chemical action. The rays emanating from the intensely hot jet of the oxyhydrogen flame, are nearly without action upon a sensitive surface of collodion; whilst if thrown upon a ball of lime, the light then emitted contains as large a proportion of chemical rays as the solar light, and of very nearly the same refrangibility. But the most remarkable source of the chemical rays is afforded by the light of the electric spark or of the voltaic arc, the chemical spectrum of which is three or four times as long as the chemical spectrum obtainable from the sun itself.

---

* The expressions here employed are simply used as descriptive of the effects ordinarily produced by the different portions of the spectrum, not as necessarily implying that the rays which produce the effects of heat, light, and chemical action respectively are essentially different, except in the number and frequency of the vibrations by which they are produced, the most refrangible rays being produced by the shortest and most frequent vibrations.

1. *Photographic Transparency of various Media.*—Amongst the methods of testing the extent of chemical action of any given radiant source, the most convenient is that which is dependent upon the extent of photographic effect exerted upon a surface of collodion coated with iodide of silver, on which the spectrum is allowed to fall.

In no case does it appear that any non-luminous source can emit chemical rays of sufficient intensity to traverse ordinary refracting media; and amongst the rays given off by various luminous objects, it is found that the chemical effects upon the collodion plate are not perceptible in those portions upon which the first three-fourths of the visible spectrum has fallen, but they commence powerfully in the last fourth; and in the case of the electric spark are prolonged to an extent equal to between four and five times the length of the visible portion.

A diagram exhibiting the relative lengths of the visible solar spectrum, and the photographic spectrum obtained from the electric spark between silver points, showed this fact in a striking manner.

It was known to those who have studied the spectrum, that many colourless substances besides glass exert an absorptive action upon some of these chemical rays; but the subject had not hitherto received that careful experimental examination which its importance seems to warrant. Exact knowledge upon these points became requisite in the course of an investigation upon the photographic spectra of the metals in which the speaker was engaged.

In the prosecution of these inquiries it was a desideratum to procure some substance which should possess a higher dispersive power than quartz, and which, whilst avoiding the double refraction of quartz, should yet allow the free passage of the chemical rays. The speaker was hence led to try a variety of substances which, owing to their transparency to light, might reasonably be hoped to possess chemical transparency also.

The inquiry soon extended itself beyond the limits originally proposed, and ultimately embraced a large number of bodies in the solid, liquid, and gaseous conditions.

Before, however, proceeding to detail the results obtained, the speaker alluded to the discovery of Professor Stokes, that many bodies exist which, when placed in the invisible extra-violet, or more refrangible portion of the spectrum, exhibit the remarkable power of absorbing the rays of this portion, and radiating them forth again in a visible form. Bodies which possess this power Mr. Stokes termed *fluorescent.* Now the chemical rays are exactly those which occasion fluorescence most powerfully. The light thus rendered visible is, however, very feeble, compared with that of the ordinary luminous portions; yet it may be rendered distinctly visible to those who are sufficiently near by allowing this chemically active portion of the spectrum to fall upon a screen consisting of some fluorescent substance, such as one of the salts of uranium, or a solution of æsculin, which latter was the material employed on the present occasion.

Returning then to the course of his own experiments, the speaker stated that although he had found in rock-salt, fluor-spar, water, and some few other substances, compounds which were almost as *diactinic,* or chemically transparent as quartz, he had not succeeded in finding anything which could be advantageously substituted for quartz in the preparation of the prisms and lenses required in the investigations in which he was engaged.

Among the most remarkable results upon the photographic transparency of bodies which had been observed by the speaker in his researches, were the following :—

1. Colourless solids which are equally transparent to the visible rays, vary greatly in permeability to the chemical rays.

2. Bodies which are photographically transparent in the solid form, preserve their transparency in the liquid and in the gaseous states.

3. Colourless transparent solids which absorb the photographic rays, preserve their absorptive action with greater or less intensity both in the liquid and in the gaseous states.

4. Pure water is photographically transparent, so that many compounds which cannot be obtained in the solid form sufficiently transparent for experiments, may be subjected to trial in solution in water.

The mode in which the experiments were conducted was the following:—

The source of light employed was the electric spark obtained between two metallic wires, generally of fine silver, connected with the terminals of the secondary wires of an induction coil, into the primary circuit of which was introduced a condenser, and into the secondary circuit a small Leyden jar. The light of the sparks was then allowed to fall upon a vertical slit, either before or after traversing a slice or stratum of the material of which the electric transparency was to be tested; the transmitted light was then passed through a quartz prism, placed at the angle of minimum deviation. Immediately behind this was a lens of rock crystal, and behind this at a suitable distance the spectrum was received upon the sensitive surface of collodion. Liquids were contained in a small glass cell with quartz faces, and gases and vapours in long tubes closed at their extremities with thin plates of polished quartz. The following tables exhibiting the relative diactinic power of various solids, liquids, and gases and vapours were then commented on.

PHOTOGRAPHIC TRANSPARENCY OF

SOLIDS.		LIQUIDS.		GASES AND VAPOURS.	
Rock Crystal	74	Water	74	Oxygen	74
Ice	74	Alcohol	63	Nitrogen	74
Fluor Spar	74	Chloroform	26	Hydrogen	74
Topaz	65	Benzol	21	Carbonic Acid	74
Rock Salt	63	Wood Spirit	20	Olefiant Gas	66
Iceland Spar	63	Ether	16	Marsh Gas	63
Sulphate of Magnesia	62	Acetic Acid	16	Coal Gas	37
Borax	62	Oil of Turpentine	8	Benzol Vapour	35
Diamond	62	Bisulphide of Carbon	6	Hydrochloric Acid	55
Bromide of Potassium	48			Hydrobromic Acid	23
Thin Glass	20			Hydriodic Acid	15
Iodide of Potassium	18			Sulphurous Acid	14
Mica	18			Sulphuretted Hydrogen	14
Nitrate of Potash	16				

The effects indicated in these tables were rendered visible to the audience, by illuminating the photographic negative of the electric sparks from silver points by the light of the electric lamp, and bringing the image to a distinct focus upon the screen by means of a condensing lens.

Each photograph was obtained under circumstances varying only in the nature of the transparent medium through which the rays of the spark from the silver points were made to pass, before they were allowed to fall upon the collodion plate. When absorption occurs, it is almost always exhibited upon the most refrangible rays; but in the case of the coloured gases and vapours, chlorine, bromine, and iodine, the absorption differs from the general rule, and is by no means proportioned to the depth of colour. A column of chlorine with its yellowish green colour cuts off the rays of the *less* refrangible extremity through fully two-thirds of the spectrum; the red vapour of bromine cuts off about one-sixth of the length of the spectrum, the absorbent action being limited to the less refrangible extremity, whilst the deep violet-coloured vapours of iodine allow the less refrangible rays to pass freely for the first fourth of the spectrum; then a considerable absorption occurs, and afterwards a feeble renewal of the photographic action is exhibited towards the more refrangible end.

Diactinic bases, when united with diactinic acids, usually furnished diactinic salts; but such a result was not uniformly observed; the silicates were none of them as transparent as silica itself in the form of rock crystal. Again, hydrogen is eminently diactinic, and iodine vapour, notwithstanding its deep violet colour, is also largely diactinic; but hydriodic acid gas is greatly inferior to either of them.

The same substance, however, whatever may be its physical form, whether solid, liquid, or gaseous, preserves its character; no chemically opaque solid, though transparent to light, becoming transparent photographically by liquefaction or volatilization; and no transparent, solid being rendered chemically opaque by change of form. Hence it is obvious that this opacity or transparency is intimately connected with the atomic or chemical character of the body, and not merely with its state of aggregation. Although the absorption of the chemical rays varies greatly in the different gases, which therefore in this action display an analogy to their effects upon radiant heat, yet those gases which absorb the rays of heat most powerfully are often highly transparent to the chemical rays, as is seen in the case of aqueous vapour, of carbonic acid, cyanogen, and olefiant gas, all of which are compound substances, not chemical elements. These observations were considered by the speaker as opposed to the view of Dr. Tyndall, that compounds, *as compounds*, act more energetically than elementary bodies in absorbing the heat-rays, owing to the greater inertia of the particles of compounds. Any physical cause of this kind ought, however, to enable such bodies to act equally as absorbents of the luminous and chemical rays.

In the case of reflection from polished surfaces, the metals were found to vary in the quality of the rays reflected; gold and lead, although not the most brilliant, reflecting the rays more uniformly than the brilliant white surfaces of silver and speculum metal.

2. *Photographic Spectra of the Elements.*—But the most interesting results are those obtained by examining the spectra produced by varying the nature of the metallic electrodes employed as terminals to the secondary wires of the induction coil. Professor Wheatstone showed twenty-eight years ago that the visible spectrum of each metal is perfectly characteristic when electromagnetic sparks are transmitted between two surfaces of the metal; and the same thing is equally true of the invisible portion of the spectrum.

Even the various gaseous media become so intensely heated by the passage of the electric spark, that they furnish photographic spectra, each of which is characteristic of the body which occasions it; and when the electric discharge of the secondary coil becomes intensified by use of the Leyden jar, the sparks not only produce the spectra due to the metals, but to the gaseous medium in which the electrodes are immersed; so that a mixed spectrum is the result. The spectra produced by the metals are characterized by bands, of which the extremities only are visible; whilst the gaseous spectra yield continuous lines, which traverse the whole width of the spectrum. When a compound gas is made the medium of the electric discharge, the spectra produced are those of the elementary components of the gas. It seems as though at these intense temperatures chemical combinations were impossible; and oxygen and hydrogen, chlorine and the metals probably might all coexist in a separate form, though mechanically intermingled.

The spectrum produced by the ignition of a solid or a liquid always yields a continuous band of light, containing rays of all degrees of refrangibility; but the same body, when converted into vapour, usually produces a spectrum consisting of a series of bright bands of particular colours, separated from each other by intervals more or less completely dark, gaseous bodies emitting rays of certain definite refrangibility only.

From the striped character of the photographic spectra, it is obvious that the vibrations are emitted from the different metals in the form of vapour, and not merely in that of detached particles projected from the electrodes by disruptive discharge.

This observation may give some idea of the intensely high temperature attained by the spark; since it is uniformly observed that the higher the temperature, the more refrangible are the vibrations. We are, indeed, furnished in this case with a rude, but still, under the circumstances, with a valuable pyrometric means of estimating these exalted temperatures.

To give an illustration of the mode of applying the observation: The hottest wind-furnace of ordinary construction yields a temperature probably not much exceeding 4,500° F. By calculations founded upon the amount of heat ascertained by Andrews and others to be emitted during the combustion of a given weight of hydrogen, and the experiments of Regnault upon the specific heat of oxygen, hydrogen, and steam, it has been shown by Bunsen that the temperature of the oxyhydrogen flame cannot exceed 14,580° F. The speaker stated that he had obtained spectra by introducing lime and sulphate of magnesia into the oxyhydrogen jet: these incombustible materials therefore could not be heated by the burning gases to a higher point than 14,600° F., but the spectra so obtained coincide in their photographic lengths with that of the solar spectrum. Hence, the temperature of the sun may be approximatively estimated to be not higher than that of the oxyhydrogen flame. It certainly appears to be far below that of the electric spark. Magnesium in the electric spark gives a remarkably strong band just beyond the limits of the solar spectrum. Now magnesium is as clearly proved to exist in the solar atmosphere as any element, if we be admitted to have any such proof at all. But inasmuch as the special band which characterizes magnesium at a high temperature in the electric spark is wanting in the solar spectrum, it is difficult to avoid the conclusion that the temperature of the solar atmosphere is below that generated by the electric spark.

The speaker then adverted to Kirchhoff's well-known theory of the origin of Fraunhofer's dark lines in the solar spectrum, based on the observation that when any substance is heated or rendered luminous, rays of a definite refrangibility are given out by it; whilst the same substance, vapour, or gas, has the power of absorbing rays of this identical refrangibility. Now Kirchhoff supposes that in the luminous atmosphere of the sun the vapours of various metals are present, each of which would give its characteristic system of bright lines; but behind this incandescent atmosphere containing metallic v
is the still more intensely heated solid or liquid nucleus of the

which emits a brilliant continuous spectrum, containing rays of all degrees of refrangibility. When the light of this intensely heated nucleus is transmitted through the incandescent photosphere of the sun, the bright lines which would be produced by the photosphere are *reversed*, and Fraunhofer's black lines are therefore the reversed bright lines of which the spectrum due to the gaseous atmosphere of the sun would consist if the intensely heated nucleus were no longer there.

From his observations Kirchhoff concluded, by a comparison of the bright lines in the spectra of various metals with the dark lines of the solar spectrum, that potassium, sodium, magnesium, calcium, iron, nickel, chromium, manganese, and possibly cobalt, were present in the sun's atmosphere; and Ångström, continuing the examination into the blue and violet extremity, believes that he has shown the existence of hydrogen, aluminum, and possibly of strontium and barium. Diagrams were exhibited, showing some of the solar lines according to the observations of Kirchhoff and Ångström, from which it appears that

B	corresponds to	potassium.
C	„	hydrogen.
D	„	sodium.
E	„	iron.
b	„	iron and magnesium.
F	„	strontium (?) and iron and hydrogen.
G	„	iron.
H	„	calcium.

These observations on the solar spectrum give great interest to similar observations upon the stars, the light of which, however, is so feeble as to render the investigation of their spectra a task of no ordinary delicacy. Fraunhofer examined four or five of the brightest stars, and considered that the light of Sirius and Castor had lines differing decidedly from that of the sun. Capella and α Orionis resembled the solar light more closely. Donati has since examined several of the brighter stars, and given a drawing of some of their lines. The speaker had recently, conjointly with his friend, Mr. Huggins, been pursuing the same investigation with the excellent eight-inch equatorial refractor of the latter, and they had obtained some interesting results, having measured the principal lines in Sirius, Betelgeus, and Aldebaran, a diagram of which was exhibited, showing a more detailed spectrum of each of these stars than had been given by any previous observer. He also projected on the screen a microscopic photograph of the spectrum of Sirius that his friend and he had succeeded in obtaining. The light of this star, from the measurements of Sir J. Herschel and Mr. Bond, is little more than the one-six-thousandth-millionth part of that of the sun; and although probably not less in size than sixty of our suns, is estimated at the inconceivable distance of more than one hundred and thirty millions of millions of miles. And yet it is influencing, in a measure, the chemical changes which are perpetually occurring upon the earth's surface, and by suitable means the changes may be recorded, estimated, and measured—the force which was registered by the photograph having emanated from Sirius twenty-one years before!

Capella, which Admiral Smyth estimates at more than three times the distance of Sirius, also gave a photograph, when its spectrum was thrown upon a collodion plate, the effect being produced by rays, which left the star probably when the oldest person in the room was yet a boy.

[W. A. M.]

WEEKLY EVENING MEETING,

Friday, March 13, 1863.

THE REV. JOHN BARLOW, M.A. F.R.S. Vice-President, in the Chair.

JOHN HALL GLADSTONE, Esq. Ph.D. F.R.S.

On Fogs and Fog Signals.

DURING the course of the inquiry made by the Royal Commission on Lights, Buoys, and Beacons, the attention of my colleagues and myself was called to the fog signals which form part of the apparatus of many lighthouses, and of all British light-ships. In the report we expressed our conviction, "that they are not sufficiently powerful, and recommend the provision of a more efficient warning in fog as subject of investigation and experiment." About the same time, some scientific men in Ireland stirred in the matter, and induced the British Association to appoint a committee, at the head of which is the Rev. Dr. Robinson, of Armagh, to bring the importance of the subject more directly under the notice of the legislature. These circumstances led me to turn my attention to fog; and I propose now to lay before you some of the results arrived at, with reference both to the meteorological phenomenon itself, and to the means adopted for preventing its disastrous consequences among the vessels that sail along our shores.

I have received voluminous returns of the occurrence of fog at about 250 stations, for which I am indebted to the kindness of the three general Lighthouse Boards,—the Trinity House, the Northern Commissioners of Lighthouses, and the Ballast Board of Dublin; also to the Board of Trade, through Admiral Fitz Roy; and to Mr.

[illegible] thanks to several gentlemen [illegible] this discourse, especially [illegible] a paper on the subject [illegible] friend Professor [illegible]

[illegible]

[illegible] In the first discourse [illegible] the formation of [illegible] and defined [illegible] of saturated [illegible] the windings of the [illegible] summer. [illegible] returns in my possession depends greatly on this, and there is reason to fear, even from internal evidence, that one lighthouse keeper calls by the name of fog what another keeper thinks sufficiently described as mist or haze. Yet these keepers have a certain general sentiment and similarity in their way of thinking, and with many the practical definition of a fog is when it is necessary to sound the signal. Among amateur observers on land the greatest discrepancy prevails; but nautical men seem to have a general agreement as to what amount of thickness is to give a claim to the designation fog. For such observations Mr. Cuningham suggests that a pole, painted vermilion, should be set up at a hundred yards from the station, and that such an amount of mistiness as renders it invisible should alone be named fog. The colour of the pole should, of course, be in strong contrast to the objects behind it. This definition is somewhere about that practically adopted by seamen; it has been accepted by Mr. Glaisher, and it is to be hoped that it will be generally adopted by all observers.

From the returns received, the following deductions may be drawn:—

I. While many fogs are quite partial in their character, others cover a large extent of country. The irregular distribution of a London fog is a matter of frequent observation. Thus, last Tuesday, the day of the royal wedding, one of the densest yellow fogs obscured Westminster, whilst at Bayswater there was nothing more than a murky mist. The long-continued fog of November last in London, extending from the 19th to the 25th, was observed also at Berkhampstead, Oxford, and Banbury, but other parts of England seem to have been clear. The occurrence of fog at the lighthouse stations all round the coast during the first six months of the year 1861 has been especially studied, and the fogs of that April have been represented on a map. Some of them cover large portions of the British Isles. For instance, that of the 14th stretched all round Ireland, except the south-west corner, crossed the Irish sea to the headlands of Wales and the south-western isles and coasts of Scotland, and made its appearance again across the mainland in the Firth of Forth.

II. Some months are marked by fogs much more than others. For instance, along the south coast of England, February and September are comparatively free, while January and June are foggy months. November is notorious for fog in London, but does not seem to deserve that character elsewhere.

III. Some years are much more visited by fogs than others. For instance, 1861 was freer than 1858 along most parts of the coast.

IV. Different localities are very variously visited by fog. England does not deserve that pre-eminent character for mistiness which is attributed to it by the popular imagination of the Continent. The value of the returns in showing the relative distribution of fog in different places is seriously affected by the different standards in the minds the observers, but the following points seem pretty clearly made

A fog is more uniformly distributed over the surface of the sea than on the adjoining coasts. Fog is not particularly prevalent about sandbanks, or low headlands; but where cliffs or high hills catch the southwest wind just after it has swept the ocean, as at the Isle of Wight, the Start Point, Lundy Island, and the Rocks of Pembrokeshire, the numbers run very high. The highest return is from Barra Head, the southernmost point of the Hebrides, where winds surcharged with moisture from the Gulf Stream strike the cold northern rocks, and wrap them in cloud or fog.

FOG SIGNALS.

As light only very imperfectly penetrates a fog, attempts have been made to warn vessels of their approach to danger, or to acquaint them with their position, by means of sound. The fog signals actually in use are as follows:—Bells are employed at many of the lighthouses, and in the Irish light-ships, the finest, perhaps, being two near Dublin, and that at the Copeland Island, in the Irish sea, which is rung by machinery, and is said to have been heard thirteen miles off. At the end of the pier at Boulogne there is a large bell, in the centre of a large parabolic reflector facing the sea. It is struck by three hammers alternately, the motive power being a falling weight. Gongs are made use of in all the light-vessels belonging to the Trinity House. Guns are fired on board the Kish light-ship, from the mountain above the South Stack Lighthouse, at Fleetwood, and elsewhere. A very powerful steam-whistle has for some time been in operation at Partridge Island, near St. John's, New Brunswick, a part of the world peculiarly affected by fog.

At the Skerries, near Holyhead, terns and other sea-birds are encouraged, as their cries serve as a warning to vessels during fog; but unfortunately some rats escaped from the 'Regulus,' which was wrecked there about seven years ago, and they are destroying the birds. A cat has been tried, but she preferred birds to rats.

The comparative efficiency of these various methods is a very serious question; indeed, there are grave objections to the use of sound at all as a fog signal. The difficulties are as follows:—A sound indicates the proximity, but not the exact direction, of a danger. In this respect it is totally different from a light. Yet the mere warning is something; and probably a suitable ear-trumpet would give a better idea of the direction than is obtained without it. There is evidence that vessels have sometimes steered by a sound; for instance,—" In the winter of 1860, the steamer 'Iron Duke' having been drawn by the flood tide to the northward past Howth, was attracted by the sound of the bell, and steered by it safely towards Kingston, until the bell on the east pier of that harbour told her of its proximity, and ultimately led her into safety." The Royal Commissioners on Lights made special inquiry about the Boulogne bell, and found that some of the captains of steamers frequenting that port could find their way in by the sound of the bell, in thick weather; at least, in conjunction with the use of the lead.

An objection to the use of most of these fog signals is the fear that they may be mistaken for other sounds, or other sounds mistaken for them. Bells are frequently being rung on shipboard; the firing of guns is the well-known sign of distress; and steamers in a fog are in the habit of whistling as they go along. Gongs do not seem open to this objection; and in the case of other sounds, it might be obviated by having a definite system of repetition, as is done with the flashing and revolving lights. My friend, the Rev. T. Pelham Dale,* has indeed suggested a means of signalling, in which musical notes are employed.

Another difficulty is, that even loud sounds cannot be heard far to windward if a breeze is blowing; but this is of less importance, as a fog usually occurs in calm weather.

But the great objection to sound as a fog signal is, that a fog stops the waves of sound as it does those of light. It is well known that sound will not traverse a heterogeneous medium, such as air loaded with mist. As to the fact of such signals being rendered inefficient by the very thing which they are intended to penetrate, the testimony of mariners is somewhat conflicting. Mr. Alexander Cuningham, who is the secretary of the Northern Commissioners of Lighthouses, says:—"Many years ago, having landed from the lighthouse tender on the small skerry in the Portland Firth, a fog came on. We hurried off in the hope of reaching the vessel; but before doing so, the fog shut her completely from our view. We pulled in the direction (having a compass) in which the tender was last seen; but those who know the rapidity and variety of the tides in that dangerous locality, will easily be prepared to hear that our efforts were unsuccessful We lay about the spot for some time, firing our fowling-pieces, and at last pulled for the shore. Next morning the vessel came in sight; and on comparing notes, we found that we must have been within a very short distance of her; and they had been firing small six-pound carronades all night, and we never heard them, nor did those on board hear our guns."

Yet, on the other hand, we have accounts of bells being heard at a distance of some miles during a fog, and the steam-whistle near St. John's is said by the captains and pilots of steamers frequenting that port to be most serviceable, and to be generally heard for four or six miles during strong breezes blowing on shore. It is, indeed, quite possible that fogs of the same intensity may still have a very different effect upon the same signal, and that for two reasons; first, one fog may reach far up into the atmosphere, presenting a high wall to every vibration; while another may be a thick layer lying on the surface of the earth, with an open space above, through which the swelling waves of sound may freely pass. Secondly, air perfectly saturated with moisture is no bad conductor of sound; a fog under such atmospheric conditions may therefore be far less obstructive than when the medium is more heterogeneous.

---

* Marryatt's Signals, ed. 1856.

Considering these objections to the use of sound as a fog signal, must we abandon it altogether? We cannot do so, as we have nothing better to substitute. We fall back upon the recommendation of the Royal Commission, that further experiments should be made, which it is hoped will be gradually adopted by the authorities, as the majority of the other scientific recommendations have been.

Experiments should be performed on the manner and degree in which fog absorbs or destroys sounds of different pitch, or of different characters,—for instance, a sharp sound or a prolonged sound; on the various means of producing loud sounds, as to their pitch, volume, convenience, costliness, &c.; whether a repetition of the same sound, or some variation in note, octave, frequency, &c., be desirable; on the influence exerted by the height above the sea at which the sound originates; on the influence of a background, such as a tower, cliff, or hill, in reflecting the sound, or of a concave mirror; on the best means of directing a sound to a particular azimuth, or of determining its direction when on board ship.

Captains Close and Nisbet, of the Trinity Board, have made some experiments on one of these points at Holyhead Mountain, where a gun was fired from near the surface of the sea, and another at a considerable height, and the respective reports were listened to from various distances at sea. They found the upper gun was heard best for six miles, after which it lost its superiority. But the most remarkable result was the irregularity of the noise from the lower gun, which, at certain points in fact was not heard at all, though the flash was distinctly seen.

Powerful means of producing sound, besides those already mentioned, have been suggested. Mr. Cowper has planned a large steam-trumpet for lighthouse stations, which may be made to revolve. There is something similar in America worked by Erichsen's engine, with which is associated the name of Mr. Daboll. And Professor Holmes, of the Magneto-Electric Light, has also a steam-trumpet, which can be adapted for different notes, and gives a buzzing sound of wonderful intensity. Suggestions on this point were also made to the Royal Commissioners by several scientific men. Thus, horns were strongly recommended by more than one; but Mr. Mallet prefers explosive sounds; and Sir John Herschel says:—"It would be worth trial, what would be the effect of a battery of whistles, blown by high-pressure steam, or by a combination of three, or several sets of three, pitched exactly to harmonic intervals (key-note, third, fifth, and octave), but all of a very high pitch, and with a rattle (analogous to the pea in a common whistle), which intensifies the action on the auditory nerve." Captain Ryder believes a gun might be constructed to produce the very distinctive sound of an explosion, followed instantaneously by a whistle.

There is another and very promising field for experiment, the transmission of sound through the water itself. The experiments of M. Colladon on the Lake of Geneva proved the great distance to which sound is transmitted through water, and the velocity and directness of its course.*

In his observations he employed a bell, let down into the water; but this is a bad instrument for signalling, as its vibrations are almost instantly stopped. Many arrangements would appear to be preferable. The Syren, which was so called by its inventor, M. Cagniard de la Tour, because it would sing under water, is well adapted to give any note that is found desirable.† Long glass tubes, vibrating longitudinally, are said to produce immense volumes of sound in water: and other means might be devised. As the sound remains in the water, it would be necessary to make some communication between it and the ear of the listener. M. Colladon employed an apparatus like a spoon, with a tube for handle. By this means a mariner might listen for signals made at any important station, such as the Lizard Point, and might not only hear them at a great distance, but determine approximately their direction, unaffected by the state of the atmosphere above.

[J. H. G.]

WEEKLY EVENING MEETING,

Friday, March 20, 1863.

Major-General Edward Sabine, R.A. President R.S. D.C.L. Vice-President, in the Chair.

Balfour Stewart, Esq. F.R.S.

On the Forces concerned in producing Magnetic Disturbances.

When a bar of steel has been magnetized, it has acquired a tendency to assume a definite position with respect to the Earth. Nothing is more widely known than this important fact, but at the same time there is nothing in Science more mysterious than its cause. We may endeavour to explain it by asserting that the Earth acts as a magnet; but whence it has acquired this magnetism, how it is distributed, and what are the causes of its many changes, are amongst the most perplexing and the most important of those problems in physical science which are yet unsolved.

---

* Mémoires de l'Académie des Sciences: Des Savans Etrangers.—Tome v.

† Ann. Chim. Phys. xii., page 171.

The force with which the Earth acts upon the needle is directive merely; that is to say, the needle is neither attracted nor repelled as a whole, but simply twisted round, and in this respect the Earth is similar to a very powerful magnet, the pole of which is placed at a great distance from the needle upon which it acts.

If we keep a magnetic bar constantly suspended in the same place, its position will be subject to many changes. In the first place, there is that change which goes on in the same direction for a great many years together, in virtue of which a needle suspended in this place 200 years ago would have assumed a position very much different from its present one. Secondly, there is a change of which the period is one year, and this is called the annual variation. Thirdly, there is a change of which the period is one day, and which is called the daily variation. Fourthly, there is a change which depends upon the moon's hour angle; and, fifthly, the needle is subject to sudden and abrupt changes in position, which are called magnetic storms and which form the subject of this discourse. During the prevalence of these unaccountable phenomena the needle is found to oscillate rapidly and capriciously backwards and forwards, being now on the one side and now on the other of its normal or undisturbed position.

It should be here remarked, that the Physicist regards the needle merely as a vane (similar to a wind-vane) which serves to render visible the direction and intensity of that mysterious force which operates through the Earth. It is really the Earth's magnetism with which he concerns himself.

Gauss, who has done so much to further the science of magnetism, showed, by means of a preconcerted system of observation, that magnetic storms affected the needle at Göttingen and at other stations in Europe at precisely the same moment of absolute time; and after the establishment of the colonial observatories, it was found by General Sabine that the needle was affected in Toronto at precisely the moment when it was disturbed at Göttingen. Nor is it too much to say, with our present knowledge, that these remarkable disturbances break out at the same moment over every portion of our globe.

Having thus shown that these phenomena are cosmical in their character, the next point of interest is their connection with the sun. This has been placed beyond doubt chiefly through the labours of General Sabine, who found at Toronto and elsewhere that magnetic disturbances obey a law of hours. Mr. Broun also showed the same thing from his observation of the needle at Makerstoun, in Scotland. It may be instructive to point out how this proof was deduced from the colonial observations; and to make the matter plain, let us refer to an imaginary case in the familiar science of meteorology. Suppose that, while an observer is watching his thermometer there is a sudden influx of cold weather, and that it is wished to estimate the influence of this upon the thermometer on a given day and at a given hour of that day, what must the observer do? He must endeavour to ascertain, by the best possible means, what indication the thermometer would have afforded at that specified day and hour had there been no cold weather. Comparing this with the actual height of the mercury, and deducting the one from the other, he would clearly obtain a measure of the effect of the cold weather upon the thermometer.

A similar course was pursued by General Sabine in discussing the colonial magnetic observations, with the object of deducing the laws of disturbances. It was first necessary to ascertain by the best possible means what position the magnet would have assumed at any particular day and hour, had there been no disturbance. Calling this the normal value, the next course was to group together as disturbed, all those positions of the magnet which differed from the normal by more than a certain small quantity. The necessity for this separation will become evident when it is remarked that the disturbed and the regular observations have different hourly turning-points, and obey very different laws. Thus a disentanglement was effected, which was accomplished by the employment of a separating value. The selection of this value is to some extent arbitrary, but it was shown by reference to a diagram that the disturbance law at Kew was virtually the same, whether this were deduced (in the case of the declination) from 95 days of principal disturbances or from all disturbed observations which differ from the normal by more than 3′·3. It was also shown from the same diagram that easterly disturbances prevail at Kew during certain hours of the day, and westerly disturbances at certain other hours, thus exhibiting a daily law, and showing that disturbances are therefore connected with our luminary.

There is, however, a more interesting and mysterious connection than this. Professor Schwabe, of Dessau, has now for nearly forty years been watching the disc of the sun, and recording the groups of spots which have been visible, and he finds that these have a period of maximum nearly every ten years, two of these periods being the years 1848, 1859. Now it was likewise found by General Sabine, that the aggregate value of magnetic disturbances at Toronto attained a maximum in 1848, nor was he slow to remark that this was also Schwabe's period of maximum sun-spots, and it was afterwards found, by observations made at Kew, that 1859 (another of Schwabe's years) was also a year of maximum magnetic disturbance. This fact is eminently suggestive, and brings us at once into the presence of some great cosmical bond, different from gravitation, adding at the same time additional interest as well as mystery to these perplexing phenomena.

These are the grounds on which we suspect the sun to be the agent which causes magnetic disturbances, but there is also some reason to believe that on one occasion our luminary was caught in the very act. On the first of September, 1859, two astronomers, Messrs. Carrington and Hodgson, were independently observing the sun's disc, which exhibited at that time a very large spot, when about a quarter-past eleven they noticed a very bright star of light suddenly break out over the spot and move with great velocity across the sun's surface.

On Mr. Carrington sending afterwards to Kew Observatory, at which place the position of the magnet is recorded continuously by photography, it was found that a magnetic disturbance had broken out at the very moment when this singular appearance had been observed.

The next point to be noticed is, that magnetic storms are always accompanied by auroræ and by earth currents. With regard to the latter of these phenomena, a single word of explanation may be necessary. Earth currents are currents of electricity which traverse the surface of our globe, a portion of which is caught up by the telegraphic wires, which are often thereby seriously disturbed in their communications. A table was then referred to, which showed that auroræ and earth currents have the same ten-yearly period as sun-spots and magnetic disturbances, so that a bond of union exists between those four phenomena.

The question next arises, What is the nature of this bond? Now, with respect to that which connects sun-spots with magnetic disturbances we can as yet form no conjecture; but we may, perhaps, venture an opinion regarding the nature of that which connects together magnetic disturbances, auroræ, and earth currents. And here we may remark that this latter bond is the more definitely determined of the two, since the three phenomena which it embraces *invariably occur together*.

In order to exhibit the evidence upon which this hypothesis rests, it is necessary to refer to what is done at the Kew Observatory.

By means of an apparatus arranged by the late Mr. Welsh, the values of the *components* of the earth's magnetism, are there recorded continuously by photography. Now there is a proposition which goes by the name of the parallelopiped of forces and which asserts that if three forces acting at a point be represented in magnitude, and in direction by the three sides of a parallelopiped, the resultant of these forces shall be represented in magnitude and direction by the diagonal of the parallelopiped. These three forces may be said to be *components* of the whole resultant force, since the joint action of the three is the same as that of the resultant.

To refer to a familiar case, suppose that there is a gust of wind which (as sometimes happens) is not horizontal, but blows downwards in a slanting direction from above. How shall we estimate the direction and the force of this wind? Let us have three pressure plates, one north and south, one east and west, and one up and down; then the north and south component of the wind will be given by the first, the east and west component by the second, and the up and down component by the third, and exhibiting the indications of these three pressure-plates by the three sides of a parallelopiped, the diagonal will represent the wind in magnitude and in direction.

Something of this kind must be done, if it be wished to record the disturbing force which acts upon the needle. Let there be three magnets free to move, two in a horizontal plane and one in a vertical direction; one swinging freely and pointing to magnetic north and south, one compelled by torsion to point to magnetic east and west, and a third balanced on a knife-edge so as to move up and down; the first will be sensitive to an east and west disturbing force, which will act at right angles to it, and tend to twist it round; the second will on the other hand be affected by a north and south force, and the third by a vertical force. It is easily seen how these three magnets will take the place of the three pressure plates, in the meteorological problem. Now if a mirror be attached to each of these magnets, it may be made to reflect the image of a dot of light upon a sheet of photographic paper, so that a small motion of the mirror shall cause a large motion of the dot, and if the paper itself move by clock-work, in a directi[illegible] at right angles to that in which the dot moves on the paper, the phot[illegible]aphic impression of the dot during a day's motion of the paper will be a curved line, and this being obtained for each of the three magnets, we shall be able to record continuously the changes which are taking place in the three components of the earth's magnetic force.

Reference was then made to a [illegible]am in which these three curved lines were exhibited for Septem[illegible]-2, 1859; and it was seen that about four o'clock in the early [illegible] of September 2, the three components of the earth's magnetism a[illegible]ew were simultaneously and abruptly disturbed, and were kept at one side of their normal or undisturbed positions for many hours. [illegible]re were vivid auroræ which extended over the g[illegible] of [illegible], and even to as low a latitude as Cuba, and stro[illegible] observed by Mr. C. V. Walker, on the various [illegible]aphic [illegible]hese currents were found to change their direction every two or three minutes, going alternately from positive to negative, and back [illegible]in to positive. It is therefore evident that currents varying [illegible]ner could not have been the cause of magnetic disturbances in w[illegible] the needle was kept on one side of its nominal position for many h[illegible]rs. But the curves of magnetic disturbance further exhibit sharp pe[illegible]d hollows, or wavelets, superimposed upon the great disturbance wave, and these wavelets change their direction every two or thre minutes, in which respect they are comparable with earth currents. May not these wavelets be connected with earth currents and auroræ, and may not this connection be of the following kind? A peak denotes a small but rapid change of the earth's magnetic force in one direction, and a hollow, a similar change in the opposite direction. Now in a Ruhmkorff's coil we have—1st, a soft iron core, with a current circulating round it; 2nd, an insulator round the current; 3rd, a secondary coil above the insulator, containing perhaps several miles of fine wire. In this arrangement we have a discharge between the terminals of the secondary coil every time contact with the primary current is made, and one of an opposite character every time this contact is broken.

But the chief use of the primary current is to reverse the magnetism of the iron core, and could we reverse this, or even change it rapidly without a primary current, we should have the same effect, that is to say, we should have a secondary current in one direction, when the magnetism of the core was rapidly increased, and one an opposite direction, when this was rapidly diminished. An experiment was made, showing the mode of action of the Ruhmkorff's coil, and the following comparison was instituted between this instrument and our earth. The body of our earth may be likened to the soft iron core of a Ruhmkorff's machine, in which one of the small curve-peaks already alluded to denotes a rapid change of magnetism in one direction, and a hollow, a change of the opposite character. The lower strata of the atmosphere again resemble the insulator of the Ruhmkorff's machine, and the upper and rarer strata, the secondary conductor; again, the crust of the earth being permeated with moisture, becomes a conductor, and may therefore also be likened to the secondary coil. Whenever therefore we have a curve-rise, that is to say, a sudden change of the earth's magnetism in one direction, we should have in the upper strata of the atmosphere and in the crust of the earth currents of one kind; and when we have a curve-fall or a sudden change of magnetism in the opposite direction, we should have similar currents of an opposite description.

It need hardly be remarked, that those currents which take place in the upper strata of the atmosphere will form auroræ, while those in the crust of the earth will constitute earth currents.

Now, if this be the nature of that connection which subsists between magnetic disturbances, earth currents, and auroræ, may we not extend our inquiries, and ask, "If the sun's action is able to create a terrestrial aurora, why may he not also create an aurora in his own atmosphere? It occurred independently to General Sabine, Professor Challis, and the speaker, that the red flames visible during a total eclipse may, indeed, be solar auroræ. In support of this hypothesis it may be remarked that, during the late total eclipse in Spain, Mr. De la Rue, by means of the Kew photoheliograph, proved that these red flames belong to the sun, and that they extended in one case to the distance of 70,000 miles beyond his photosphere. But, considering the gravity of the sun, we are naturally unwilling to suppose that there can be any considerable amount of atmosphere at such a distance from his surface; and we are therefore induced to seek for an explanation of these red flames amongst those phenomena which require the smallest possible amount of atmosphere for their manifestation. Now the experiments of Mr. Gassiot, and the observed height of the terrestrial aurora alike convince us that this meteor will answer our requirements best. And besides this, the curved appearance of these red flames, and their high actinic power in virtue of which one of them, not visible to the eye, was photographed by Mr. De la Rue, are bonds of union between these and terrestrial auroræ.

It has been remarked by General Sabine, that an auroral outburst in the sun may perhaps be responded to simultaneously by the different planets. If this be true, our whole solar system would seem to thrill almost like a living being under the excitement of this mysterious force. It has been likewise found by Mr. Gassiot, that electricity cannot pass through a perfect vacuum, so that perhaps we have only to observe the greatest height attained by a terrestrial aurora and by a solar red flame, in order to be able to assign the limit, not only of our own atmosphere, but also of that of our luminary.

One other point remains to be noticed in connection with magnetic disturbances, and this is, that there appear to be two separate disturbing forces, nearly opposite in character, both connected with the sun, which act simultaneously upon the magnet; the position which the latter assumes being due to the combined effect of both. This has been shown to be true by General Sabine, who has observed that the curve which exhibits the daily range of the east component of the disturbing force, is in many places very different in character from that which exhibits the same for the west component. And this difference between the two curves is of one kind at one station, and of another kind at another station. This duality of the disturbing forces may also be observed directly in the Kew disturbance-curves. Here it was shown, by means of models, kindly constructed by Mr. Beckley, and also by reference to the parallelopiped of forces, that whenever the corresponding peaks and hollows for the different components continue to bear a definite proportion to one another, these then denote the action of a disturbing force, varying in intensity, but always preserving the same type.

A set of curves were exhibited in which this proportion held, and in which the disturbing force, whose variations were denoted by the peaks and hollows, was one which affected the north and south component twice as much as the other two. It was then shown by reference to the normal line, or line of no disturbance, that there was also in action at that time another disturbing force, which was not however of the same variable character as that which caused the peaks and hollows.

The attention of foreign men of science has been much directed to the problem of terrestrial magnetism, and five sets of magnetographs, similar to those in operation at the Kew Observatory, have been already procured by foreign governments. These, however, will be placed in the northern hemisphere, and it is to be desired that some of our colonies in the southern hemisphere may come forward in order that by the next epoch of maximum disturbance (1869), there may be such a network of magnetic observatories as may enable us to obtain the solution of this interesting and important problem.

[B. S.]

WEEKLY EVENING MEETING,

Friday, March 27, 1863.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

WILLIAM CROOKES, ESQ. F.C.S.

On the Discovery of the metal Thallium.

THE speaker commenced by remarking that the discovery of a new metal was no novelty in this century. Since its commencement, our knowledge of the material world had been increased by the discovery of no less than thirty-two of these elements. Glancing rapidly at the already known metals, the speaker said that seven of these were known to the ancients, and we have no knowledge of their first discovery. We know, however, that many are found native, and the others are separated from their ores either by heat alone, or by heat and the simplest chemical agencies. Most of those of more recent discovery have been obtained by exclusively chemical means, the exceptions being those, the separation of which, by means of voltaic electricity, by Sir Humphry Davy, makes the commencement of this century a marked epoch in the history of chemistry, and also of the Royal Institution. From the time of Sir Humphry Davy no new method for the recognition of elements had been discovered until the researches of Bunsen and Kirchhoff gave to the scientific world a definite knowledge of analysis by means of the spectrum. By this means Bunsen discovered the two new alkali metals cæsium and rubidium, and by the same means the speaker was led to the discovery of Thallium.

The special history of the discovery of the last-named metal offered a curious parallelism to the discovery of selenium by Berzelius. The great Swedish chemist was engaged on the examination of a residue from a sulphuric acid manufactory, in which he was induced to suspect the presence of tellurium. A complete examination proved to him that tellurium was absent; but in the course of his experiments he succeeded in separating a new element, belonging to the sulphur group, to which he gave the name of Selenium. The speaker, three years ago, was occupied in the analysis of a similar residue from some sulphuric acid works at Tilkerode, also with a view to the separation of tellurium. The sulphuric acid residue had originally been placed at his disposal by Professor Hofmann, in the year 1850, for the purpose of extracting selenium from it. In the distillation of the crude selenium, there was left behind in the retorts a residuum which a few chemical tests led the speaker to conclude contained tellurium. This was placed aside for further examination, and remained unnoticed until, in the beginning of the year 1861, it was re-examined with the object of preparing tellurium from it. Not succeeding in finding evidences of the presence of this metal by chemical means, the speaker had recourse to the recently discovered means of spectrum analysis; but instead of noticing the alternate bands of light and shade characteristic of tellurium, he was surprised to observe a single green line of remarkable brilliancy and intensity, which had hitherto been unnoticed, and was communicated by no known element which could have been present in the residuum. (The spectrum of thallium was here projected on the screen, a 40-cell Grove's battery being used to produce the electric arc. Its green band appeared perfectly sharp and brilliant upon a dark background.) Further researches soon proved to the speaker that he was, in fact, dealing with an entirely new element; but the quantity contained in the material under analysis was so minute that the complete isolation was a matter of great difficulty. In September, 1861,[*] however, and by means of the galvanic battery, he succeeded in precipitating the metal in a pure form; to which, in consequence of the green band it communicates to the spectrum and to flame, he had previously given the name of Thallium, from θαλλός, a bud, the colour of early vegetation most nearly resembling the shade of green it gives. The metal was shown to friends soon after isolation, and its nature freely communicated; but no formal publication of this fact was made until the opening of the International Exhibition, on May 1, 1862, where, in a case deposited some days before, were displayed several grains of the new body, labelled and described as a *heavy metal.*

By the kindness of numerous friends, among whom may be mentioned Dr. Thornthwaite, Professor Chandelon, and Mr. Peter Spence, and by the munificence of the Royal Society, he has since found more prolific sources of the metal, and been able to work on a large scale.

While speaking of the metallic nature of Thallium, the speaker noticed the fact of the observation of the green line and separation of the metal, on the 16th of May last, independently of himself, by a skilful Belgian chemist, M. Lamy, who deposited a specimen in the International Exhibition in June, 1862.

Thallium, the speaker said, belongs to the class of heavy metals. Its specific gravity is 11·9, very nearly that of lead. In colour it most resembles cadmium. It possesses considerable lustre, but quickly tarnishes in the atmosphere. It is very soft, being easily scratched by lead. It is very malleable, and the speaker showed that it could easily be forced into wire, several lumps welding together in the cold into one solid rod. It marks paper like plumbago, but the mark quickly disappears by the formation of a light-coloured oxide, being reproduced however by the action of a soluble sulphide. Thallium, the speaker showed, was strongly diamagnetic, being only inferior to bismuth in this respect; and Dr. Matthiessen had determined that its power of conducting electricity was very near that of lead. It is precipitated from its solution by means of the battery in beautiful crystals, the form of which has not yet been determined; and when the experiment is carefully conducted, these spread over the dish in branches like a delicate seaweed, or with a stronger solution like the club-moss. The atomic weight of thallium is about 203. Its chemical properties are at first sight rather anomalous, and seem to justify the remark of M. Dumas, that it is the ornithorhynchus of metals. That eminent French chemist ranks it with the alkaline metals, with which indeed it has some common properties: but the speaker is inclined to class it with the heavy metals, lead and silver, to which it seems more nearly allied both by its chemical and physical properties: several of the chemical reactions of thallium were shown in corroboration of this view. Like the metals potassium and sodium, it forms a soluble oxide which is endowed with strongly alkaline properties; like them too it is not precipitated by sulphuretted hydrogen, nor in its lower state of oxidation by an alkali; it also forms an insoluble platino-chloride, but here the resemblance ceases. All the other reactions are similar to those of the heavy metals. The soluble oxide is in reality also allied to the oxides of silver and lead (which are both soluble in water and alkaline), inasmuch as it has no affinity for water, being rendered anhydrous even at the common temperature in a vacuum. It is readily precipitated in the metallic form from its saline solutions by zinc. It forms an insoluble peroxide, sulphide, iodide, bromide, chromate and sulphocyanide, and a slightly soluble protochloride, sesquichloride, ferrocyanide and chlorate.

---

[*] At the Lecture, the year 1862 was given inadvertently for 1861.—[W. C.]

The alloys of Thallium have not yet been much studied. The uses of the metal the speaker said he was hardly yet in a position to dwell upon. At present it would appear only to confirm in the most striking manner the value of spectrum analysis as a guide in chemical research. As an agent for the production of colour in pyrotechny, it was only equalled in brilliancy by the two other elements which give a monochromatic light, lithium and sodium. The speaker here illustrated the monochromatic nature of the thallium light, by throwing the magnified image of its electric arc on a bouquet of variously coloured flowers; and concluded by thanking the audience for the indulgence they had extended to his first public discourse.

[W. C.]

Royal Institution of Great Britain.

WEEKLY EVENING MEETING,

Friday, February 6, 1863.

Colonel Philip James Yorke, F.R.S. in the Chair.

James Glaisher, Esq. F.R.S.

On Scientific Experiments in Balloons.

he introductory part of the discourse, Mr. Glaisher gave a brief
ry of aërostation, from the discovery of the fire-balloon in the year
2, by the two brothers Montgolfier, noticing some of the principal
nts made with fire-balloons. He then spoke of the discovery of
endish in 1776, *viz.* that hydrogen gas was fully ten times lighter
common air; when it immediately occurred to Dr. Black, of
nburgh, that if so, a thin bladder filled with this gas ought to rise
tself: yet a period of several years elapsed before this obvious
erty was applied to the inflation of balloons; not in fact till
success of the fire-balloon was established. He then spoke
he more remarkable ascents and experiments which were made
air-balloons within a few years of its discovery, and remarked,
the result of the several experiments having proved that
balloon would raise great weights in the air, and remain for a
time thus suspended, caused a general desire to navigate the
regions of the atmosphere, and to pursue meteorological and
r investigations in those regions, and the invention of the balloon
looked upon as likely to be followed by great consequences. He
spoke of the different ascents which have been made in the
rests of science: the first of which was that of Mr. Boulton, well
wn as the partner of the famous Watt, who constructed a balloon
hich a match and serpent were attached, that the gas might explode
he air. The object was to determine whether the reverberating
d of thunder was caused by echo or by successive explosions; the
t remained unsettled owing to the shouting of the people; but it
thought that the sound did resemble thunder.

This experiment was made on December 26, 1784. No further
riments were made, so far as he knew, till the beginning of the
ent century, when in the years 1803 and 1804, Mr. Robertson

made three ascents from St. Petersburg, for the purpose of making magnetical and other experiments.

On August 23, 1804, MM. Gay-Lussac and Biot ascended from Paris for a similar purpose; they attained an altitude of 13,000 feet, and found no difference in their experiments in electricity, magnetism, and galvanism from those made on the earth.

On September 15, Gay-Lussac ascended alone to a height of 22,977 feet; he found that the temperature declined from 82° to 15°; that the sky was deep blue; that the time of horizontal vibration of a magnet was shorter with elevation.

In 1806, Carlo Brioschi, Astronomer-Royal at Naples, endeavoured to ascend higher than Gay-Lussac; the balloon burst, but its remnant happily checked the rapidity of the descent.

A period of forty-four years followed, during which no systematic attempts were made to take scientific observations by means of balloons.

In 1850, MM. Bixio and Barral inflated a balloon with hydrogen gas, in the gardens of the Observatory at Paris, with the intention of ascending to a height of from 30,000 to 40,000 feet; in their first ascent they ascended to a height of 19,000 feet, and descended to the earth in 47 minutes; they passed through a mass of cloud 9000 feet in thickness.

In their second ascent, clouds were reached at 7000 or 8000 feet, which proved to be 15,000 feet in thickness; they never, in fact, passed out of the clouds; for when they were 23,000 feet high, they began to descend, owing to a rent in the balloon.

Mr. Welsh's experiments were made in the year 1852: on August 17 and 26, October 21, and November 10, the respective heights attained in these were 19,500 feet, 19,100 feet, 12,640 feet, and 22,930 feet: a great number of observations were made, from which the following law regarding the decline of temperature with elevation was deduced:—

"That the temperature of the air decreases uniformly with the height above the earth's surface, until at a certain elevation, varying on different days, the decrease is arrested, and for a space of 2000 or 3000 feet the temperature remains nearly constant, or even increases by a small amount: the regular diminution being afterwards resumed and generally maintained at a rate slightly less rapid than in the lower part of the atmosphere, and commencing from a higher temperature than would have existed but for the interruption noticed."

These results, as well as those found by Gay-Lussac relative to the decline of temperature with increase of elevation, appeared to confirm the law which theory, based upon observations upon mountain sides, assigns for the gradation of temperature; *viz.* a decrease of one degree of temperature for every increase of 300 feet. Up to the present time therefore the high expectations entertained on the discovery of the balloon have never been realized.

The speaker then proceeded to state, that since the formation of the British Association, grants of money have been made for the purpose of pursuing these inquiries; but with the exception of those by Mr. Welsh, none have been made.

In the year 1861, another grant of money was made, and a committee appointed to carry out experiments by means of the balloon, and the task of making these experiments was undertaken by the speaker.

The primary objects of the experiments with which he was entrusted were:—

The determination of the temperature of the air and its hygrometrical states at different elevations up to five miles.

To compare the readings of an aneroid barometer with those of a mercurial barometer up to five miles.

To determine the electrical state of the air.

To determine the oxygenic state of the air by means of ozone papers.

To determine the time of vibration of a magnet on the earth, and at different distances from it.

To determine the temperature of the dew point by Daniell's Dew Point Hygrometer, Regnault's Condensing Hygrometer, and by the use of the Dry and Wet Bulb Thermometers as ordinarily used, and by their use when under the influence of the aspirator, so that considerable volumes of air are made to pass over their bulbs, at different elevations, as high as possible, but particularly up to those heights where man may be resident or where troops may be located, as in the high lands and plains of India, with the view of ascertaining what confidence may be placed in the use of the Dry and Wet Bulb Thermometers, by comparison with the results as found from them and with those found directly by Daniell's and Regnault's Hygrometers; and to compare the results as found from the two hygrometers together.

To collect air at different elevations.

To note the height and kind of clouds, their density and thickness at different elevations.

To determine the rate and directions of different currents in the atmosphere.

To make observations on sound.

To note atmospherical phenomena in general, and to make general observations.

The speaker then described the method of managing a balloon, spoke briefly of the several ascents already made, and then proceeded to speak of some of the results.

Speaking of the ascent on July 17, the departure of the temperature from a regular progression was very remarkable. Below the cloud the decrease was nearly uniform; on passing above it there was an increase of 6°; the decrease was then resumed, and the temperature was 26° at 10,000 feet, and continued at this reading till 13,000 feet had been passed; a very remarkable increase then took place, and at 19,500 feet a temperature of 42° was registered, and then declined rapidly to 16° at five miles. In descending, a disturbance from a regular increase was met with at 24,000 feet, and continued to 17,000 feet; at 13,000 feet clouds were reached and no observations were made below 10,000 feet.

The temperature of the dew point approached that of the air in the cloud but did not touch it, and then separated more and more until at the highest point there was almost an entire absence of moisture.

On August 18, the temperature of the air decreased as usual on leaving the ground, until at the height of 4000 feet the rapidity of the decrease was checked and a warm current of air was met with and continued to 11,500 feet; the balloon then descended and passed through the same warm current extending to the same limits, and again passed through it on its reascension at about the same height, and extending to 14,000 feet, when the regular diminution was resumed and continued to the highest point; on descending, the same warm current was met with, and continued till the clouds were entered at 6500 feet, which caused another interruption in the regular increase of temperature as is usual on entering cloud.

In the ascent on September 5, on passing out of the cloud there was an increase of temperature of 9°; and then no interruption was met with till a height of 15,500 feet was reached, when a warm current of air was reached, and continued to 24,000 feet: then a regular decrease was experienced till the highest point was reached.

On descending, the same warm current was encountered between 22,000 and 23,000 feet; and a similar interruption, but to a greater amount, was experienced till the balloon had descended to about the same height as it was first met with on ascending. After this there was no further interruption till the descent was completed.

A table was then formed from all the observations, showing the decrease of temperature for successive increases of elevation of 1000 feet. The results are as follows:—

When the Sky was Cloudy.

	Ft.		Ft.		Deg.				Deg.		Ft.
From	0	to	1000	was	4·7	from	7	experiments, or	1	in	213
,,	1000	to	2000	was	4·2	from	7	,,	1	in	239
,,	2000	to	3000	was	4·1	from	10	,,	1	in	244
,,	3000	to	4000	was	3·7	from	10	,,	1	in	271
,,	4000	to	5000	was	3·1	from	6	,,	1	in	323

From these results it will be seen that when the sky is cloudy, the decline of temperature differs very little from the theory of a decline of temperature of 1° in 300 feet.

But When the Sky is partially Clear.

	Ft.		Ft.		Deg.				Deg.		Ft.
From	0	to	1000	was	7·2	from	5	experiments, or	1	in	139
,,	1000	to	2000	was	5·3	from	5	,,	1	in	189
,,	2000	to	3000	was	4·6	from	5	,,	1	in	254
,,	3000	to	4006	was	3·4	from	6	,,	1	in	295
,,	4000	to	5000	was	2·7	from	7	,,	1	in	370

These results differ considerably from those formed in a cloudy sky, and doubtless the difference between experiments carried on under a cloudless sky would differ still more. They do not at all confirm the theory of a decline of 1° of temperature in 300 feet.

The Decrease of the Temperature of the Air, at heights exceeding 5000 feet.

	Ft.		Ft.		Deg.					Ft.
From	5,000	to	6,000	was	2·8	from	10	experiments, or	1 in	357
„	6,000	to	7,000	was	2·8	from	8	„	1 in	357
„	7,000	to	8,000	was	2·7	from	8	„	1 in	370
„	8,000	to	9,000	was	2·6	from	8	„	1 in	384
„	9,000	to	10,000	was	2·6	from	8	„	1 in	384
„	10,000	to	11,000	was	2·6	from	8	„	1 in	384
„	11,000	to	12,000	was	2·6	from	6	„	1 in	384
„	12,000	to	13,000	was	2·5	from	6	„	1 in	400
„	13,000	to	14,000	was	2·2	from	6	„	1 in	455
„	14,000	to	15,000	was	2·1	from	9	„	1 in	477
„	15,000	to	16,000	was	2·1	from	9	„	1 in	477
„	16,000	to	17,000	was	1·9	from	9	„	1 in	527
„	17,000	to	18,000	was	1·8	from	9	„	1 in	556
„	18,000	to	19,000	was	1·8	from	9	„	1 in	556
„	19,000	to	20,000	was	1·5	from	9	„	1 in	667
„	20,000	to	21,000	was	1·3	from	9	„	1 in	771
„	21,000	to	22,000	was	1·3	from	9	„	1 in	771
„	22,000	to	23,000	was	1·0	from	9	„	1 in	1000
„	23,000	to	24,000	was	1·3	from	2	„	1 in	771
„	24,000	to	25,000	was	1·1	from	2	„	1 in	909
„	25,000	to	26,000	was	1·0	from	1	„	1 in	1000
„	26,000	to	27,000	was	1·0	from	1	„	1 in	1000
„	27,000	to	28,000	was	0·9	from	1	„	1 in	1012
„	28,000	to	29,000	was	0·8	from	1	„	1 in	1050

These results follow almost in sequence with those found with a partially clear sky; and together show that a change takes place of 1° of temperature in 139 feet near the earth, and only in 1000 feet at the height of 30,000 feet, and plainly indicates that the decline of 1° of temperature must be abandoned.

Treating the observations for determining the degrees of humidity of the air in the same way, the following are the results:—

When the Sky was cloudy, saturation being considered as 100,

On the earth the degree of humidity was . . .			78	from	5	experiments.
At the height of	1,000	the degree of humidity was	76	„	9	„
„	2,000	„	77	„	11	„
„	3,000	„	75	„	11	„
„	4,000	„	80	„	10	„
„	5,000	„	81	„	5	„
„	6,000	„	82	„	3	„

The law of moisture here shown is an almost uniform state of humidity to the height of 3000 feet, *viz.* 76·5; then a decrease on the next 1000 feet, and an increase to 83 and 82 at 5000 and 6000 feet.

When the Sky was partially Cloudy.

On the ground		the degree of humidity was . . .	63	from 4	experiments.
At the height of	1,000	the degree of humidity was	68	„ 5	„
„	2,000	„	77	„ 5	„
„	3,000	„	76	„ 5	„
„	4,000	„	76	„ 7	„
„	5,000	„	69	„ 6	„
„	6,000	„	68	„ 6	„

At heights exceeding 6000 feet, the following were the results:—

	Ft.				
At the height of	7,000	the degree of humidity was	64	from 7	experiments.
„	8,000	„	58	„ 7	„
„	9,000	„	52	„ 7	„
„	10,000	„	82	„ 7	„
„	11,000	„	48	„ 5	„
„	12,000	„	48	„ 8	„
„	13,000	„	43	„ 5	„
„	14,000	„	58	„ 2	„
„	15,000	„	53	„ 3	„
„	16,000	„	45	„ 3	„
„	17,000	„	33	„ 3	„
„	18,000	„	21	„ 2	„
„	19,000	„	36	„ 2	„
„	20,000	„	33	„ 1	„
„	21,000	„	12	„ 1	„
„	22,000	„	31	„ 1	„
„	23,000	„	16	„ 1	„

The laws of moisture here indicate a humidity near the ground less by 15 with a partially clear sky, than in a cloudy sky; starting with 63 in the former state on the ground, increasing to 77 at 3000 feet high; then nearly constant to 5000 feet, when it abruptly decreased to 69 and 68 at 5000 and 6000 feet, and then decreased nearly evenly at the rate of 5 in 1000 feet, till at 9000 feet and 10,000 it was 52; the degree then constantly decreased till at a height exceeding 25,000 feet it was less than 10, and it would seem that at higher elevations there was an almost entire absence of water. These seem to be the general laws; but this regular diminution is evidently often interrupted, and strata of moist air may exist, or be passing at different elevations, even up to 20,000 feet, of some thickness.

Electrical State of the Air.—In the ascent on July 17, the air was found to be charged with positive electricity, becoming less in amount with increased elevation, till at the height of 23,000 feet the amount was too small for observation. The instrument was broken in the descent, and was not afterwards used.

Time of Vibration of a Magnet.—The general result of all the experiments is, that the magnet vibrates in a *somewhat longer interval* of time at higher elevations than on the earth. This result is contrary to that found by Guy-Lussac in 1804.

On the Propagation of Sound.—From observation made in the different ascents, it was learnt that different notes and sounds pass more readily through the air than others; for instance, the barking of a dog and the whistle of a railway engine have been heard at a height of more than two miles, whilst the shouting of several thousand people cannot be heard at the height of one mile.

On the Oxygenic-Condition of the Atmosphere.—On July 17, the test papers by Moffat and Schönbein were untinged by colour throughout the journey; and the same result was found during the ascent on July 30th.

On August 10, Mr. Glaisher received a letter from Dr. Moffat, of Hawarden, expressing surprise at this result, inasmuch as it has always been received as a theory, that ozone increases in quantity with increased elevation.

In consequence of this, Mr. Glaisher went to Dr. Moffat, at Hawarden, and requested him to make some papers, which he did, and these papers were used on August 18, together with some prepared by Messrs. Negretti and Zambra, and some prepared according to Schönbein's formula; and at 22,000 feet the coloration was 4 on a scale whose deepest tinge is 10, whilst those prepared by Schönbein were coloured to 1 on the same scale, and those by Negretti and Zambra were uncoloured; in consequence of this, the preparation of the papers by Messrs. Negretti and Zambra has been stopped.

Physiological Observations.—On July 17, before starting, the number of Mr. Coxwell's pulsations were taken, and found to be 74 in one minute; and Mr. Glaisher's were 76 in one minute.

At a height of 17,000 feet, Mr. Glaisher's had increased to 100, and Mr. Coxwell's to 84; and on reaching the ground, the number was 76 with both gentlemen.

On August 21, no observations were taken before starting. At the height of 1000 feet, the following results were obtained:—

Mr. Coxwell	96	per minute.
Mr. Ingelow	80	„
Capt. Percival	90	„

At 11,000 feet—

Mr. Coxwell	90	in a minute.
Mr. Ingelow	100	„
Capt. Percival	88	„
Mr. Glaisher	88	„
Master Glaisher	89	„

At 14,000 feet—

Mr. Coxwell	94	per minute.
Mr. Glaisher	98	„
Mr. Ingelow	112	„
Capt. Percival	78	„
Master Glaisher	89	„

The pulsations of Capt. Percival were so weak that he could scarcely count them; whilst those of Mr. Coxwell he considers had increased in strength.

From these results it will be seen that diminished pressure exercises a different influence upon different individuals.

On July 17, at 19,000 feet the hands and lips were noted as being dark-blue, not the face. At the height of four miles the palpitations of the heart were audible, and the breathing was affected.

On August 18, the hands and face were blue at the height of 23,000 feet.

On September 5, at the height of about 29,000 feet Mr. Glaisher became unconscious, and at 35,000 feet Mr. Coxwell lost the use of his hands. At 29,000 feet on descending, Mr. Glaisher began to recover, and at 25,000 feet the observations were resumed.

The general results of these eight ascents are :—

1st. That the temperature of the air does not decrease uniformly with the height above the earth's surface, and consequently the theory of a decrease of 1° of temperature for an increase of elevation of 300 feet must be abandoned. In fact, more than 1° declined in the first hundred feet when the sky was clear, and not so much as 1° in 1000 feet a height exceeding five miles.

These experiments are the first to yield any definite information on the subject; more experiments are required to settle the law satisfactorily, but its effect on the laws of refraction will be great: all the elevations of the balloon are to a certain extent erroneous, for it has never happened that the mean of the extremities has given the mean of the whole column of air.

2nd. The degree of humidity decreased wonderfully with the height till at above 5 miles there was scarely any aqueous vapour at all.

3rd. That an aneroid barometer can be made to read correctly, to the first place of decimals certainly, and to the second place of decimals probably, to a pressure as low as 7 inches.

4th. That a dry and wet bulb thermometer can be used effectively up to any height on the earth's surface where man may be located.

5th. That the balloon does afford a means of solving with advantage many delicate questions in physics.

[J. G.]

GENERAL MONTHLY MEETING,

Monday, April 6, 1863.

The Rev. J. Barlow, M.A. F.R.S. Vice-President, in the Chair.

Leveson Francis Vernon Harcourt, Esq. B.A.
William Harvey, Esq. F.R.C.S.L.
Joseph Norman Lockyer, Esq. F.R.A.S.
Paul Julius Reuter, Esq.
Octavius Sturges, Esq.
Frederick Thompson, Esq. and
Robert Wigram, Esq.

were *elected* Members of the Royal Institution.

Lieut.-Col. Craven Hildesley Dickens, R.A.
Abraham Pope, Esq.
John R. Russell, M.D. and
John Rivington, Esq.

were *admitted* Members of the Royal Institution.

The Special cordial Thanks of the Members were returned to Warren De la Rue, Esq. Ph.D. F.R.S. Manager R. I. for his Present of a Ruhmkorff's Magneto-Electric Induction Coil of a particular construction.

Sir Roderick I. Murchison, K.C.B. D.C.L. F.R.S. Manager R. I. having announced his intention of presenting to the Institution annually £20, for the purchase of Scientific Apparatus, the Special cordial Thanks of the Members were returned to him for this additional evidence of his great goodwill towards the Institution.

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Imperial Government of France (*through M. Rouland, Minister of Public Instruction*).
Œuvres de Lavoisier. Tome II. 4to. 1862.
Mémoires Militaires relatifs à la Succession d'Espagne. Tome XI. & Atlas. 4to. 1862.

Geological Survey of Great Britain (*through Sir R. I. Murchison*)—Mineral Statistics, 1860, 1861. 8vo.
Memoirs, Six Parts, 1859-62. 8vo.

Governor-General of India—Geological Survey of India.—Palæontologica Indica. Part 2, No. 3. 4to. 1862.

Actuaries, Institute of—Assurance Magazine, No. 51. 8vo. 1863.
Agricultural Society of England, Royal—Journal, Vol. XXIV. Part 1. 8vo. 1863.
Anthropological Society of London—Introductory Address, by James Hunt, Ph.D. the President. 8vo. 1863.
Astronomical Society, Royal—Monthly Notices, Feb. 1863. 8vo.
Calvert, Dr. F. Crace, F.R.S. (the Author)—Lectures on Coal-Tar Colours. (K 89) 8vo. 1863.
Chemical Society—Quarterly Journal, New Series, No. 3. 8vo. 1863
Civil Engineers, Institution of—Proceedings, March, 1863. 8vo.
Editors—Artizan for March, 1863. 4to.
  Athenæum for March, 1863. 4to.
  Chemical News for March, 1863. 4to.
  Engineer for March, 1863. fol.
  Horological Journal, No. 55. 4to.
  Journal of Gas-Lighting for March, 1863. 4to.
  Mechanics' Magazine for March, 1863. 8vo.
  Medical Circular for March, 1863. 8vo.
  Practical Mechanics' Journal for March, 1863. 4to.
  Technologist for March, 1863. 8vo.
Franklin Institute of Pennsylvania.—Journal, No. 446. 8vo. 1863.
Hamilton, Sir Charles, Bart. C.B. M.R.I.—Sir W. H. Holmes on Free Cotton: with a Map of British Guiana. (K 89) 8vo. 1863.
Horticultural Society, Royal—Proceedings, 1863, No. 3. 8vo.
Linnean Society—Proceedings, No. 25. 8vo. 1863.
Newton, Messrs.—London Journal (New Series) for March, 1863. 8vo.
Petermann, A. Esq. (the Editor)—Mittheilungen aus dem Gesammtgebiete der Geographie. No. 2. 1863. 4to.
Philadelphia, Academy of Natural Sciences—Proceedings. 1862. No. 7–12. 8vo.
Photographic Society—Journal, No. 131. 8vo. 1863.
Royal Society of London—Proceedings, No. 54. 8vo. 1863.
Statistical Society—Journal, Vol. XXVI. Part 1. 8vo. 1863.
Tyndall, Professor J. F.R.S. M.R.I. (the Author)—Heat considered as a Mode of Motion: being a Course of Twelve Lectures delivered in 1862. 16to. 1862.
  Official Illustrated Catalogue of the International Exhibition of London, 1862. 4 vols. 8vo. 1862.
Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Nov. Dec. 1862. 4to.

WEEKLY EVENING MEETING,

Friday, April 17, 1863.

: DUKE OF NORTHUMBERLAND, K.G. F.R.S. President,
in the Chair.

FRANK BUCKLAND, Esq. M.A.

On the Culture of Fish.

some introductory remarks on the growing importance of the the speaker proceeded to lay before his audience a series of btained by close observation, which promise to become the ' the origin or increase of revenue to private individuals, and a f national wealth.*

od barn-door fowl produces about 120 eggs in a year. The g table gives the result of Mr. Buckland's own observations on

The Fecundity of Fish.

	Weight of Fish.	Total Number of Eggs.
Salmon and Trout†	1 lb.	1,008
Jack	4½ lb.	42,840
Perch	½ lb.	20,592
Roach	¾ lb.	480,480
Smelt	2 oz.	36,652
Lump Fish	2 lb.	116,640
Brill	4 lb.	239,775
Sole	1 lb.	134,466
Herring	½ lb.	19,840
Mackerel	1 lb.	86,120
Turbot	8 lb.	385,200
Cod	20 lb.	4,872,000

hard roe is composed of the eggs; the soft roe is the milt of . The eggs are very closely packed together, somewhat

---

. Buckland's entire Discourse, with Additions and an Appendix, has been , under the title of "Fish Hatching," by Mr. Tinsley, price 5s.

out, like salmon, carry, on an average, 1000 eggs to every pound of their but this rule does not apply to trout under a pound. Again, as regards , the heavier they are the more eggs they carry.—From a specimen of ius *Piscatorius* (the angler-fish) sent to him from Brighton in February, . Buckland obtained a substance resembling a ribbon 6¾ yards in length, tudded with ova, about the size of turnip-seed—from which billions of sh might have been produced. The number of young oysters on the he old one at spawning time is estimated at 1,800,000.

resembling figs in a box. The colour of the eggs varies, some being white and others of a splendid coral-red colour; all equally good. The eggs are exceedingly hard and tough, and very elastic; which prevents them from being crushed or otherwise injured.

How the Fish deposits her Spawn.—Birds build with twigs and other vegetable material. The salmon and trout can make no use of these materials, so they deposit their eggs among stones. Other fish, especially sea-fish, make use of vegetable material; either, as in the case of the stickle-back, building a true nest, or else depositing the eggs upon the fronds and leaves of the plants, somewhat after the manner of insects.

When the fish (the salmon and trout) are about to spawn, they choose, above all places, a shallow gravel bottom; the reason being that there shall be a more rapid flow of water, and hence a greater supply of oxygen to the eggs themselves and also to the young ones when born. The most natural breeding-grounds for the salmon are small, rapid, mountain streams, deep pools being in the neighbourhood, wherein they can rest and take shelter. They, doubtless, ought to have pools; because a salmon does not deposit her ova at one and the same time, but at intervals. During these intervals she drops back into the pool, and recruits her strength for further operations. From this we may learn much as regards the increase of salmon by natural means.[*] One knows the salmon's nest by observing in the bed of the river a hillock, or mound of gravel, about a wheelbarrow full, and a hollow sort of ditch in front of it, as though some one had been scraping it up with his heel. At the spawning season the male salmon has an enormous beak, a huge finger-like projection at the top of his lower jaw. [Two preparations of this were shown to demonstrate this fact; and also a coloured diagram, carefully drawn from nature, by Mr. Jennins.] This beak is not bony, but a mass of purely cartilaginous growth from the bone below. It disappears, moreover, when the salmon is not breeding. Mr. Buckland concludes that it is simply an offensive and defensive weapon, and is analogous to the horn of the deer.

Enemies of Ova.—1. Accidents at the time of spawning. Many of the eggs do not get properly impregnated at the time of spawning, or not being caught by the gravel, are washed away constantly by the stream. Then down come the floods and overwhelm the nests with mud and rubbish, or else sweep them bodily away, level to the bed of the river. Here is a case in point:—Mr. Buist wrote in 'The Field,' March, 1863, "From eighteen salmon and twenty-grilse we had filled our breeding-boxes with 275,000 ova. Immediately *after* our ponds were filled the rivers came out in great floods, which dispersed the salmon, and, it is feared, that as these floods continue till the end of December, the fine appearance of fish would come to little account when left to all the contingencies of spawning in the rivers. The 310 fish not spawned would all be ripe within ten days, so that from those left to *their natural course* there would not have been so many fecundated eggs from the 310 as we have in the breeding-boxes from the forty fish. All these fish were caught on one ford where the Almond joins the Tay." Then again we have droughts; and the nests made when the water is high become bare and exposed to the air when the water goes down; either the eggs die from this cause, or else the young when hatched out, having no water, "refuse to exist." Great destruction of spawning fish is also caused by mill-wheels.

---

[*] This is the meaning of the salmon making such vigorous efforts to get up from the sea to the higher waters. Instinct seems to tell them that the young will die in shallow water; they therefore make superpiscine efforts to get up cataracts and waterfalls, and attain the shallow brooks. Give them free passage up, and protect them when there, and they will increase and multiply exceedingly. Mr. Ashworth, in a letter to Mr. Buckland, says:—"We find, and I have seen it, that the smallest streams of pure water are the safest, the most productive, and the very places selected by the parent fish for depositing their ova; and if protected for two months in the winter (December and January), any river may be made productive in which the weirs are made passable by ladders, and all natural and insurmountable obstructions, such as rocks, and cascades, and falls, are made accessible, and in which the waters are the purest."

2. Fish eat the eggs; and these not only minor fish, but trout, who wait below the nest and scramble for the eggs. Mr. Buckland has himself taken trout eggs from a trout's mouth.

Mr. Ashworth states that he has taken no less than 500 peas (fish eggs) from the maw of one trout. He placed these by themselves in a hatching-box, and most of them in due time produced young fish. Salmon, too, will eat their own eggs, and we used formerly to see salmon ova, preserved in salt, sold at the fishing-tackle shops for bait. This mode of fishing is so deadly, that it is now made illegal.

3. Other enemies of fish are water-insects innumerable, especially the water-shrimp, the caddis-worm, the larva of the May-fly, the dragon-fly, &c. Messrs. Ashworth, of Galway, report that in one year 70,000 salmon ova, deposited by them in a pure stream adjoining a plantation of fir-trees, were entirely destroyed by the larva of the May-fly.

4. Human poachers.—At the time of spawning, the salmon or trout, usually as wild as a fox, becomes as tame as a barn-door fowl, and any little boy walking by the side of the stream can kill them with a stick; they become the easy prey of the poachers, and millions of their eggs are destroyed which would otherwise have been deposited. Tons weight are at this time captured and sent to Paris. These fish are poisonous to Englishmen. Mr. Ashworth's head-bailiff once ate a portion of one, and in consequence was made so ill that he was confined to his bed for two days, and he was a strong, powerful, healthy man. The British Fisheries Preservation Association are doing their best, by appeals and representations to Government authorities, both in England and France, to stop this destructive export of spawning fish.

5. Birds, &c.—Mr. Buckland brought forward strong evidence to prove that the Water-ouzel and Dab-chick were rather the friends than the enemies of fish-culture, since they feed on the larva of insects. House-rats will greedily devour the ova, and will go into the water to get at them; and it is said that the water-shrew eats the ova; his teeth are insectivorous, but still he may eat fish-eggs. Swans are *most*

destructive, particularly in ponds. In the river Thames, they do incalculable mischief to the fisheries, gobbling up the newly-laid spawn with their long beaks and spoon-like bills. Common ducks do the same.

Mr. Buckland's directions for successful FISH-CULTURE are here given in detail:—

On the Protection of the Eggs, and Hatching them by Artificial Means.—Instead of allowing the ova to be deposited in the natural nest, we catch the fish in a net, we take the eggs from her, we treat them in the manner which was first discovered by two poor fishermen (honour to their memory) and afterwards developed by M. Coste, professor of embryology at Paris.

We have to provide an artificial nest, and an artificial mother. The former consists of gravel placed in a narrow box, either of wood, earthenware, or zinc; the latter consists of a stream of shallow water, which shall be running night and day.

A model of the boxes used by Mr. Ashworth was exhibited. It was made of elm, oak, or deal, and six feet long, eight inches deep, twelve inches wide,—an enlarged mignonette box in fact. The two requisites are a running stream and shallow water. You must fix the box according to your locality. You can place it either in a narrow, fast-running ditch which you know will never fail you, or, better still, place it near a spring where you can regulate the flow of water by means of hatches, large or small. You must guard both the entrance and the exit of the box with a bit of perforated zinc, the holes of which must be sufficiently large not to obstruct the current of water; and you should also have a plate of perforated zinc fixed in any convenient place, a foot or two above the box, to stop the scum, &c., of the water. Above this may be placed an extra sentry, *viz.* a new birch-broom; saw off the handle close to the twigs, and fix it with the loose ends of the twigs pointing up stream. These twigs will catch the weeds and other mess that comes down with the water. The cleaner the water you pass into the eggs, the better for them. You should have wire covers, which can be padlocked to the boxes, to keep out the shrew-mice and rats, and the fingers of meddling boys; and you should have boards ready to place over these to keep out the light during the incubation of the ova. These boxes may be multiplied *ad infinitum*, so that the water that passes through No. 1 should fall into No. 2, and so on, like water falling down (only at the ends) from one step of a staircase on to the step below it. The box should be a little inclined, to favour the flow of water; and the water should have a fall from the end of one box into the head of another of a few inches. You must take care so to level and arrange the boxes as that, should the stream from above fail, *some* water should always be left to cover the eggs. If you have not convenience for placing the boxes in a parallel row, you can place them side by side, at right angles to the stream whence the water is derived, having a hatchway for each.

Your boxes being all ready for putting down into the stream, get me gravel. River gravel will not do; but dig it out of a gravel pit, ft it through a sieve—the meshes of which are half an inch—and hen you have enough sifted, *boil it* for an hour or so in a copper till is quite clean. The boiling destroys the sporules of the vegetation, nd also the eggs of the minor water-beasts that eat the spawn. Then et the mason or the carpenter to fix the boxes in the stream, or better o it yourself; get the levels right by means of bricks, wedges of wood, c., and then wheel down the gravel to the place; then, with a spade, arefully deposit in the boxes your boiled half-inch sized gravel, to e depth of about two or more inches. You must then place a layer f about one inch in thickness, or one and a half, of gravel stones—take hem as they come—each stone being about the size of a walnut. The eason of this stratification, is that the young fish, being hatched under he big stones, shall not get down much below this level, being stopped y the half-inch gravel. Set your stream going for a few hours, and e that it works properly, being always about two or three inches in epth, and flowing perpetually.

When you have got the eggs, carefully distribute them with a poon among the big stones under which they will naturally roll,—nd leave them alone. The stream should be gentle and conti- uous, but not fast enough to bother the eggs. With all your pre- autions for keeping the stream clear, you will find a deposit settle n the eggs, and this to a greater or less extent. To avoid this, *eep them dark;* put boards over the tops of the boxes, and, if you lease, get some common roofing slates, and place these on your alnut-sized stones, taking care that the water shall flow freely under hem. You will find the slates will catch the deposit which falls rom above downwards, and you can easily take them out and wash hem when dirty. It is, in my opinion, a mistake, to actually bury he eggs in gravel; the slates and the walnut-sized stones are suffi- ient protection. All you want is darkness, which is unfavourable to egetation, and your boards and your slates will do all this.

There is no objection to your lifting up the stones every now and hen, to see that the eggs are all right, and to pick out the dead ones, .e. those that are turned white, either with a forceps or a glass tube f the right diameter, to catch the egg.* You may, too, brush the ggs with a soft camel-hair brush, but do it gently—very gently—as moving them disturbs the vivification of the young fish that is going n inside. When the egg is developed, as will be explained hereafter, here will be no danger whatever in moving them. So much, there- ore, for the *out-door* apparatus. The *in-door apparatus* can be fixed p in a green-house, or other convenient place, and can be watched vith greater ease without exposure of the person to the cold during he winter months, during which the process of hatching will be going n. The in-door apparatus consists of a series of boxes, about the size of mignonette boxes, or even smaller, which may be made either of zinc or earthenware. The water can be caused to flow from a cistern, and will run down through as many boxes as you please to place one above the other, either side to side, or else end to end. These boxes must contain either a series of glass rods, upon which the eggs can sit, and which is a neat and clean way of hatching them, or can be filled with the *boiled* half-inch gravel, so that two inches of water can be always running over them; regulate your stream by means of stop-cocks, and find a place for the waste water to run. The water would be all the better for being filtered. This is not absolutely necessary, if it is naturally pretty pure, but it is certainly advisable. Filter it through charcoal, gravel, sand, or any other simple and commodious material. The *same* water, if clean, may be used over and over again; but fresh water is, of course, preferable.*

---

* Put your finger on the top of the tube, pass it down to the egg you wish to atch, take your finger off, and the egg will mount instantly into the tube.

All things ready, place your ova either on the glass rods or on the gravel; have a bit of board ready, fitting the tops of the boxes accurately, to keep out all the light (which is so favourable to vegetation), and look at the eggs every morning, to see how they are getting on. You should also support, by means of stones or pegs fixed into the gravel, bits of roofing slates over the eggs, to prevent the deposit, after the manner suggested for the out-of-door boxes.

Some of the eggs die. The egg, instead of being a bright pink and fresh colour, turns to an opaque, or pale white colour. Remove it instantly, for it will most assuredly contaminate all its neighbours.

Do not disturb the eggs more than you can possibly help. If the deposit is very great, attend to your filter; carefully increase the stream of water, and in time you will be rewarded by observing that the egg is vivified. You will know this by observing that two black specks appear in the egg, which are the eyes of the future fish, and you will also see a faint line running around nearly three-quarters of the egg, the body of the future salmon or trout. When you see this, congratulate yourself, for the egg is alive, and will probably hatch out all right.

The time of the eye appearing, and of the young fish hatching out, depends entirely upon the temperature. Temperature greatly affects the development of the ova into the young fish. It is a beautiful provision of nature, that the young fish should not be hatched out *too soon*, too early in the year, and acquire its mature growth before the food on which it subsists is to be found, but that they should both be produced simultaneously. Keep therefore your temperature low, or you will hatch your fish out too early in the season. 'The Field' window began to hatch on the 16th of January, at the temperature of 52° to 55°. The Zoological fish did not begin to hatch till Jan. 21, the temperature being from 48° to 50°. The temperature made all this difference. The fish which take the longest time to hatch are always the strongest fish of the two.

---

* If the reader does not understand this, let him call at the 'Field' Office, 346, Strand, and see my apparatus at work.

This is the experience at Stormonfields as regards temperature, as oted by Mr. Buist. Of the 275,000 ova in our boxes, the whole are ow (March, 1863) quick and bursting into life; a great many of hem are already hatched, and the others are very healthy, and the oung fish may clearly be seen in them, and are bursting the shell aily. In consequence of the fine open winter, the eggs have hatched i our ponds in 115 days, and have done so corresponding to the days n which the eggs were deposited. Thus the eggs on the 13th of November have hatched on the 8th of March, and have continued oing so in the corresponding days. In former seasons they have aken from 130 to 140 days, according to the temperature of the water. In spring water flowing from the rock in winter, where the emperature is always equal, the eggs have been hatched in about 60 ays. The proper temperature of the water, both in and out of doors, ught to range from 40° to 45°. Mr. Ponder's observations tell him hat at this temperature *it requires thirty-five days for the eyes to ppear (i.e. that the fish is formed in the egg), and that they hatch ut fourteen days afterwards;* this same result has been obtained by im for two seasons following with very little variation. The first fish gain hatched out from a batch are the weakest, the last are the healthiest; when however they once begin to hatch they will come out ll in a mass, two, three, or four thousand of a morning. The proper emperature for trout and salmon eggs is 40° to 45°, and anything over 0° is weakening.

Young Fish.—When Mr. Buckland first received salmon and trout ggs from Huningue, the eyes of the young fish were just visible as wo small jet-black specks—the sign that they will bear transport; the il globules could also be seen in the substance of the egg, and the ail of the fish could be observed moving from side to side with a rapid vibratory movement. The young fish increased in size daily, and very morning their growth was plainly perceptible; more especially could be noticed the form of the head, and the *darkening* of the transparent substance which would eventually be the body. He ascertained he fact. The eggs do *not* grow—*i.e.* they do not increase in circumference or in diameter—but the fish *inside* them most certainly increases n bulk, till at last it becomes so large that the egg-shell suddenly bursts, and out comes the young fish. We begin with a globule of albumen (or white of egg); we see within it a faint line, and two black spots; day by day these become larger till the young fish is born. Time goes on; the umbilical vesicle is absorbed, the colour appears on the scales, the long single crests which one observes at birth as running down the upper and lower parts of the body, resolve themselves, as it were by magic, into the various fins distinctive of the adult creature, and we have a perfect fish before us.

It is most interesting to watch the egg at the moment of hatching. If you happen to be gazing on a particular egg, of a sudden you will ee it split in twain at the part corresponding to the *back* of the fish; you will then see a tiny head with black eyes and a long tail pop out, and you will see the new-born creature give several convulsive shudders in his attempts to quit himself from the now useless egg-shell.

Mr. Ashworth gives the following observations as regards the increase of weight in the young salmon :—The fry, at three days old, is about two grains in weight; at sixteen months old, it has increased to two ounces, or 480 times its first weight; at twenty months old, after the smelt has been a few months in the sea, it has become a grilse of eight and a half pounds, it has increased sixty-eight times in three or four months; at two years and eight months old it becomes a salmon of twelve to fifteen pounds in weight. After which, its increased rate of growth has not been ascertained; but by the time it becomes thirty pounds in weight it has increased 115,200 times the weight it was at first.

In the case of the fish, nature has packed up all the nourishment that it will want for some six or eight weeks in a neat little bag or parcel, which she has affixed to the body of the fish in such a manner that it shall be gradually absorbed into the general system ; the fish does not suck milk like a warm-blooded animal, so its lower jaw is not developed. What is then the most important organ to the young fish? He has numerous enemies, and it is his first object to get out of their way. The *eyes*, therefore, are the organs which first arrive at perfection; and they are indeed perfection in this minute, jelly-like creature. The eye is in perfect working order at the moment of birth, though the rest of the body is far from perfection. The lining coats of the eye, moreover, are already at birth painted with that beautiful silver-and-gold lining which the angler will see if he cuts open the eye of the next fish he kills. It is especially well seen in the eye of the cod. This eye, however well suited for the purposes of avoiding danger, is by no means tolerant of light; a fact which Mr. Buckland observed and immediately acted upon, for one day he found to his horror that many of the young salmon (the first lot) in 'The Field' apparatus were beginning to die. He therefore got some bits of zinc and some stones, and built miniature bridges in the tanks. He touched the salmon one by one, and three out of four of them swam away under the bridges in a moment. Subsequently for plates of zinc he substituted bits of common slate, such as are used for roofing houses. Those who rear young fish should, therefore, above all things, recollect the necessity for making " hides " for the fish.

Deformities.—Fish are sometimes born with deformities. Mr. Buckland, with the assistance of Professor Tyndall and his electric lamp and microscope, exhibited on a screen a double fish — salmon twins united, having one tail and one umbilical bag. He also exhibited the figures of four or five young fish just hatched, full of activity.

Treatment of Young Fish.—All the young fish having hatched out, Mr. Buckland's advice is certainly to leave them in the boxes till the umbilical vesicle is absorbed. They do not want any food, for they are supported by the contents of the umbilical vesicle, and at this time above all others require protection. It is at this time many young fish die from what is called "gill fever." A tenacious white fungus attaches itself to the gills, and in a short time completely obstructs the action. There is no remedy for these diseases, except separating the fish, that they shall not be overcrowded, causing the stream of water to be increased, and attending to the hides and general cleanliness. By looking to these points you will save many fish, both in your outdoor and indoor boxes.

When the umbilical bag is empty they will begin to feed by the mouth, and at this time if not fed they will peck at each other's tails. The French authorities recommend at this time that they should be fed with the boiled flesh of frogs powdered into minute bits. The Stormonfields authorities use boiled liver, powdering it in their hands, and throwing it in. Another food is the fresh roe of the sole, plaice, whiting, or other small sea-fish, not salted, or the least decayed. Mix it up with a stick in clean water, and put a little of the water among the fish. They will also eat minute water-insects, red worms, flies, &c.

Turning out Fish.—A great question now arises as to the period at which they should be let loose into the waters, which the rearer of them wishes to stock. Mr. Ashworth expresses himself as being of the opinion that if they are turned out at once (*i.e.* when they begin to feed), they will, from various causes, be lost to the river. Both he and the Stormonfields authorities always keep their young fry in ponds, and feed them till they put "on their jackets," *i.e.* assume the smolt coat, and go of their own accord to the sea. It must be recollected that the conditions of the waters of the regular salmon rivers are very different to those of the Thames. But, however, Messrs. Ashworth and Buist are, no doubt, right in their opinions as practical men, in regard to the salmon. Mr. Ponder and Mr. Francis Francis are in favour of turning the fish out *into the Thames* at once—*i. e.* when they begin to feed: because if the fish is turned down in a state of babyhood, he has to "graduate through all his difficulties," and learns to shift for himself. Mr. Buckland's advice to experimenters as regards the Thames and other southern waters, is to turn out with a gentle hand the young fish on to quiet and undisturbed shallows in the main river; or else into an ever *flowing* (not stagnant), broad, weed-containing pond or ditch, whence the young fry can escape into the stream when they please. It is also advisable to keep some of them in a ditch, containing from one to three feet deep of flowing (not rapid) water, for the sake of comparing them with the fish that have been turned out into the open. A water-cress bed is a capital place.

Transport of Ova and Fish.—At Huningue the newly-taken eggs are placed in their hatching-boxes, and there allowed to develop themselves till the *eyes of the fish are plainly seen in the egg.* Then, and not till then, can you move the eggs. If you attempt to do so *before* the eye is seen, they will most assuredly die. Wait, therefore, till you see the eyes developed in the eggs you wish to send away.

The following is the best mode of proceeding:—Procure some wide-mouthed bottles, three or four inches high—common pickle-bottles or tumblers will do very well;—place at the bottom of the bottle or tumbler a layer of fresh moss (this must have been well washed previously), then dip it in clean cold water, and squeeze the superfluous water out, so that the moss shall be wet, but not dripping. Portions of rough sponge, the size of a walnut, well cleaned, are as good packing as moss, and are cleaner (these must also, of course, be damped). Upon the layer of moss deposit a layer of your "eye-showing" eggs, and arrange them so that they shall not touch one another. Place another layer of moss, another layer of eggs, and so on till the bottle is full; but there must be no pressure anywhere. Pour out any water that has collected at the bottom of the bottle, cover the top with a bit of common paper, and stab some holes in it with a penknife. Your bottles being all filled, get a stout but light box—arrange your bottles in it in the most convenient position, and stuff them down quite tight with moss that is dripping wet with water, put the cover on the box and fasten it securely. Then place this box inside another box, leaving about two or three inches of interspace. Fill this up quite tight with wet moss, and send them off by the quickest route of transport to your friend. If possible, give them in charge to a friend, or the guard of the train, and avoid exposing them to heat or to cold. This is the mode used at Huningue with so much success. Directly the eggs are received the moss should be picked out carefully with a pair of forceps, and the eggs placed immediately in the apparatus ready to receive them.

The *Young Fish* can also be carried long distances, and this is in almost any kind of vessel. It is not necessary to keep these vessels steady; moderate splashing of the water helps to oxygenate it. Change the water as often as you can, say every two or three hours; and if you see the fish getting sickly, blow air into the water by means of a common pair of kitchen bellows, or by means of an ordinary shilling pewter squirt: or use the admirable, simple, and inexpensive aërating apparatus sold by Mr. Wright, fishing tackle-maker, of 376, Strand, which the transporters of live-bait for jack-fishing have found so useful.

To show what a great distance young fish will travel, Mr. Buckland stated that he had received a few weeks since some young salmon from Gothenburg, in Sweden. They arrived perfectly sound and well late on Monday evening the 13th. There were twenty-six live fish, and one egg on the point of hatching out. The vessel they came in is simply a gigantic water-bottle. These salmon, though very healthy at first, died away one by one. The heat of the mid-day sun upon the boxes was fatal to them; but they would have lived if they had been placed in better and cooler water.

Great efforts have been made to transport salmon to Australia, and the Australian government has voted large sums of money for this purpose. Mr. Buckland believes the key to success has been discovered at last: it is "freezing the ova." This is *the* question of the day in the transport of useful fish for long distances.

What has been done, and what remains to be done.—We must, of course, give preference to the magnificent establishment at Huningue, near Basle, a noble example of what has been already done, by perseverance and energy in a good cause. In this wonderful establishment the eggs of fish are kept, and advanced in their hatching till they arrive at the period at which they will bear travel. It is by these means that many rivers in France are actually repeopled with fish, employment given to hundreds of poor fishermen, and the food of the people greatly increased. The fish cultivated are as follows:—1. Truite commune. 2. Truite saumonée. 3. Truite grande des lacs. 4. Saumon du Rhin. 5. Ombre chevalier (Charr). 6. Ombre commune (Grayling). 7. Saumon du Danube. 8. Fera. The number of eggs distributed is enormous. In 1861, the total quantity of fish-eggs distributed was *sixteen million, four hundred and forty thousand, four hundred.*

To several French scientific gentlemen the highest possible praise should be accorded by the English people—especially to M. Coste, who, having arranged a system for the artificial propagation of both marine and fresh-water fish, is, as it were, the father of pisciculture; and to that liberal-minded man, M. Coumes, the engineer of Huningue, who has so liberally distributed many thousand eggs of fish throughout Her Majesty's dominions during the last season, and to whom we owe the greatest acknowledgments, as well as to the French government, which makes distributions of the eggs of the best kinds of fish gratuitously to all the proprietors of rivers in France who will undertake to hatch and protect them, and make a return of the quantity so produced.

In England, Mr. Thomas Ashworth, of Cheadle, Cheshire, and his brother, the owners of the Galway fishery, have literally repeopled with salmon various streams that previously had no salmon in them, as well as a district of their fishery of thirty miles long by ten wide. They have also opened up a great extent of water, *viz.* a great number of tributary streams from the Claregalway river up as high as Ballyhaunis. Messrs. Ashworth commenced artificial propagation of salmon at Oughterard, in Galway, the same season that the French commenced at Huningue, neither party being aware of what the other was doing at the time. At least 659,000 salmon ova were collected, impregnated, and transported into these rivers, in December, 1861, from the adjoining streams of Claregalway, where the parent fish are found in great abundance.

The total cost of placing 770,000 salmon eggs in the fish nests or hatching boxes, and of transporting the salmon, has been *eighteen pounds*, in addition to the regular and weekly cost of his staff of water-bailiffs and workmen. The fisheries have benefited by Messrs. Ashworths' exertions to an enormous extent. There are twenty fish now to be seen, where there was one before. The little fish go down to the sea, and come back big fish, good, marketable food.

Scotland also has done much for her fisheries. The establishment at Stormonfields, on the Tay, is now a household word, and the observations, both practical and scientific, made by Messrs. Buist and Brown, are of the greatest importance.

In regard to the money value of salmon fisheries in the aggregate, it is stated that England produces annually about *ten thousand pounds* in money value; Scotland nearly *half a million of pounds;* and Ireland about *three hundred thousand pounds* annually.*

The extent of rivers in England is much greater than in Ireland, but they do not produce more than about *ten thousand pounds* per annum. There is a district in Yorkshire about 600 miles of rivers—the river Ouse, the Derwent (72 miles), Swale (71 miles), Ure (61 miles), Whurfe (75 miles), Midd (55 miles), &c. These are all good, pure rivers, with fine mountain streams, and extending over thousands of square miles, and do not produce salmon worth *one thousand pounds* a year, and are as capable of being cultivated and rendered productive as Messrs. Ashworths' river was when they purchased it, and commenced breeding and protecting the fish. To aid in remedying this deficiency, Mr. Ponder in April last placed in the Thames, near Hampton, 76,000 young fish (*viz.* 10,000 salmon, 50,000 trout, 3,000 charr, and 13,000 grayling), the ova having been presented by M. Coumes, the engineer of the establishment at Huningue, on behalf of the French government.

Dr. P. L. Sclater and the authorities of the Zoological Society, have devoted the entire end at their aquarium-house at the Gardens to the demonstration of the science of fish-hatching. The apparatus was ably designed and arranged by A. D. Bartlett, Esq., Resident Superintendent of the Gardens, and a great number of fish has been hatched out during the past few months.

What has been done in France may surely be done in England. Many gentlemen have now seen the importance of pisciculture, and have already, at the cost of a few pounds, turned a useless stream of clear running water into a vivifier of thousands of fish.† I trust more will imitate them. What we require is a regular Government establishment, as in France, where the art should be carried out and brought to perfection, and eggs distributed to every part of this our own favoured land; this may be done at a comparatively small expense.

[F. B.]

---

* See 'Report of Commissioners of Fisheries.'

† I here give a list of those who have constructed fish-hatching boxes, after either Mr. Ponder's or my own plans. His Grace the Duke of Argyll; The Viscount Powerscourt; The Earl of Mountcharles; Lady Dorothy Neville; S. Gurney, Esq., M.P.; Alfred Smee, Esq.; Captain Berkeley, 2nd Life Guards; J. Baker, Esq., of Bayfordbury; J. Hibbert, Esq.; S. Hall, Esq., of Farningham; J. King, Esq., Watford.—[F. B.]

WEEKLY EVENING MEETING,

Friday, April 24, 1863.

Duke of Northumberland, K.G. F.R.S. President,
in the Chair.

Alexander S. Herschel, Esq. B.A.

On Luminous Meteors.

m meteoric, from the Greek μετὰ ὅρον, beyond the boundary,
of particular examination, applies to all objects removed from
ce of the Earth. Neither Halos, however, Lightning, nor the
are properly included in the term " Luminous Meteors," since
are luminous by borrowed light, the second and third un-
manifestations of electricity. The term is properly confined
oblematical phenomena of shooting stars and fireballs, and the
appearances of falling stones or aerolites. The prevalence of
y in the air presents one among the reputed causes of fireballs
ting stars, but affords no explanation of the repeated descent
from the air of definite and constant lithological structure.

e year 1752, Franklin in America, and Dalibard in France,
l electricity from the air, of the same kind as ordinary machines
erto supplied for their experiments. The electrical condition
mosphere has been studied since that time by De Saussure and
ctricians, but without such a complete success as leaves nothing
sired. Free negative electricity at the surface of the earth,
ve in the highest strata of the air, is supposed to exist per-
r, producing by induction discharges of electricity from clouds
er to those of a lower level suspended in the air. The calorific
hanical effects of the flash of lightning can be imitated on the
ale by the electricity of machines. Fulgurites, or lightning
glass powder, have been produced a quarter of an inch in
nd upwards. Glass to the thickness of two inches has been
y the electric spark, while the dispersion of oxalic acid crystals
ischarge of the Leyden jar exemplifies in a striking manner the
suddenness of the elevated temperature. The electrical
ation of a *moving* discharge, termed globe lightning, and said
asionally observed, has alone defeated the imitative powers of
nters. This is the only phenomenon upon which an analogy
fireballs or shooting stars and electrical displays in the lower
re has been maintained. Should the fact of its occurrence be
o satisfaction, and its origin be discovered, the extreme rarity
r at heights in which meteors exhibit their brightest light for-
extension of the effect from the region of the clouds to that of
mpty space.

From numerous accounts of fireballs the following appear to be the characteristic features of their appearance. A starlike point, of a saffron or orange hue, moving with moderate speed, increases gradually, or continues to advance for a considerable time with constant lustre. More or less suddenly the point expands with a white or bluish light of great intensity. The expansion may even surpass the apparent diameter of the moon, and the light and colour may become so powerful as to cause a red and dull appearance of that satellite should the meteor pass closely near her disc. In this state the appearance of the meteor is rarely globular; but more commonly kite-shaped or pear-shaped; of a crescent form, followed by a straight or conical protracted train of wings and tongues, or by a single short tail of light, less intense than the crescent portion in advance. In round and oval fireballs an envelope of red sparks occasionally surrounds the head; in all, the largest of the sparks issuing from the rear of the nucleus form a dull-red extension of the tail, and sharing partly in the motion of the meteor, pursue the latter upon the track at various intervals, until the spectacle is past. At other times they form in more or less detached clouds a permanent luminous streak, enduring many minutes, with curious variations of its form, after the disappearance of the meteor. In kite-shaped or crescent-like meteors these parcels and clouds of light are left, with a red glow, by the fading tongues of flame that follow on the head. They never extend widely to the sides, but like the smoke of flame attend sluggishly in the rear of the projectile in a track rarely wider than a single degree of arc.* At the moment of greatest expansion, followers, in the form of flakes and spheres of light, attend in pursuit of the meteor on the tail. The head never divides itself *laterally*, into parts proceeding far with equal pace and brilliance. Lastly, the brilliant blue ball of a large meteor may vanish without sparks or followers or train of light, but with a tremulous appearance unravels a phosphorescent long-enduring streak of white light, which remains to mark the path in which it moved. Or, in a few meteors of the larger kind, no white or blue focus of the light, but without atmospheric absorption, an orange or red hue is seen in all the parts of the figure just described. Their manner of disappearance is without any fixed rule. Fireballs either pass away gradually as if by the mere effect of distance, or at the moment of greatest expansion break into parcels t like that of the meteor itself, rapidly fading into ruddy sparks. frequently collapse quickly to a single ruddy spark, or *quite sud-* disappear. At some points of the flight of a large meteor, and ways at the termination of its course, violent concussions are pro- audible over wide extents of country and occasioning sensible s in the air. The following list of remarkable fireballs exem- the principal characteristics here described, and invites attention opinions formerly entertained by geometers respecting the nature e luminaries.

---

* "The production, continuance, gradual change of form, and descent and final dissolution of these trails, may be familiarly but correctly illustrated by comparison with the similar succession of phenomena characterising the trail of smoke and soot issuing from the funnel of a steamship during its progress on its course, in which also a rectilinear beam of finely divided solid matter separated from flame and smoke, often several miles in length, becomes a persistent trail and gradually changes into a waved or serpentine form. In many cases the trail of a meteor must have been originally a cylindrical beam, constituted as now explained, having a diameter of many hundred yards, equal to or greater than that of the meteor itself, and a length of many miles, deposited in an inclined direction at heights of some miles above the earth's surface."—*Original Note, by E. W. Brayley, Esq., F.R.S., in 'Phil. Mag.,'* 1st ser., vol. lxiv., p. 288 (1824).

TABLE I.

.	Place.	Description.	Remarks.
31.	Bologna, Sienna. Adriatic to Sardinia. 30 miles over Leghorn.	Oval; ¼ mile by 1¼ miles. Detonated.	"Probably a cosmical concourse of atoms." (Halley, 1714.)
10.	Gravesend. Essex to Devonshire.	Long arm, and a large knob which broke into parcels.	"Probably a comet." (Wallis, 1677.)
19.	Leipzig, and Germany, 30 miles high.	Half as large as full moon. Almost stationary.	"The light remained seven minutes." (Kirch.)
10.	Sheerness, 40 miles high.	Died away. Light like the moon.	"A pale whiteness, and a streak, remained." (Halley.)
19.	England. Hereford to Plymouth, 65 miles high.	Effaced the moon. White, with blue eye. A red streak remained some minutes. Detonated.	"Probably a burning train of vapours." (Halley, 1719.)
6.	Cambridge, Carlisle, Glasgow, to Rossshire. 95 miles high to 30 miles high.	Like daylight. Flat headed. Tail conical, and broke into parcels. Detonated.	"A flame, like spirit, ran back upon the course at last." (Dr. Pringle, 1759.)
18.	Vertical over Athol, York, Dunkirk, and Burgundy. 57 miles high.	Like Mars; then daylight. Tail broke into parcels over Lincoln, with detonation and change of course. Exploded, 15° wide, over Paris, and went to horizon, S.E.	"Probably a globe-discharge of electricity." (Dr. Blagden, 1784.)
29.	Westphalia.	Size of the moon. Broke into morsels without noise. Bluish.	A yellow streak remained half an hour; double-pointed; brightened quickly at the centre.
13.	Mecklenburg.	Large fireball. Parted into fragments.	A streak of light remained fifteen minutes.
16.	Kent, Isle of Wight. 170 miles high, to 65 miles high.	Bluish. Bright as the young moon. Unravelled a permanent streak.	A streak of light continued five minutes.

e accounts recently collected for the British Association of e, present numerous reports upon the appearance of eleven large fireballs over England in the years 1861–63. From these the true trajectories and the illuminating powers of the different meteors have been calculated according to the following table.

TABLE II.

Date.	Course.	Height in Miles.		Diameter of ignited Globe.
		Appearance.	Disappearance.	
1861, July 16.	Ostend to Newcastle, 85 miles east.	172 miles	45 miles	22 feet.
1861, July 16.	North Foreland to Plymouth, 65 miles south.	195 miles	65 miles	28 feet.
1861, Nov. 12.	Peterborough to Lundy Isle, and onwards.	95 miles	60 miles	40 feet.
1861, Nov. 19.	Paris to Norwich . . .	55 miles	30 miles	36 feet.
1861, Dec. 8.	Hull to Castleton, Isle of Man, 20 miles east.	110 miles	45 miles	49 feet.
1862, Feb. 2.	Lyme Regis to Cheadle, Staffordshire.	196 miles	15 miles	24 feet.
1862, Feb. 23.	Stockport to Aberystwith .	40 miles	20 miles	14 feet.
1862, Sept. 19.	Canterbury to Oxford . .	83 miles	33 miles	36 feet.
1862, Nov. 27.	Mouths of Scheldt to mouth of Seine.	30 miles	28 miles	36 feet.
1863, Mar. 4.	Yarmouth, 60 miles north, to Liege, Flanders.	95 miles	15 miles	33 feet.
1863, Mar. 23.	Chale, Isle of Wight, 15 miles south, to Purbeck Island, 70 miles south.	55 miles	15 miles	16 feet.

In the numbers of the last column a globe of ignited ordinary coal-gas one yard in diameter, at the distance of one mile, is supposed to shine with the power of full moon, and the diameters of similar globes truly representing the light of the meteors is calculated from the original descriptions, and the known distances of the observers from the light. As meteors have been known to produce dazzling effects by day, their light cannot be greatly inferior to that of burning gas, nor the diameters of the luminous globes greatly exceeding the approximations here obtained. The figure of least resistance, originally proposed by Mr. Brayley, and also by Dr. Haidinger, of Vienna, for the true construction of a fireball, is that of a pear-shaped envelope of incandescent air springing from the foremost surface of a solid missile, and drawn with occasional nodes to a long distance in the rear. The flash perceived in a fire-syringe made of glass is illustrative of the luminous effect ascribed in this theory to the compression of the air, while the lime-light and the brilliant combustion of magnesium in oxygen gas are examples of the brilliance imparted by certain solid bodies to flames of very intense heat. In the recent experiments of M. Ste. Claire Deville, on the dissociation of water, it was shewn that the heat of solid fuel is sufficient to destroy completely the chemical affinity of oxygen for hydrogen; and the same conclusion is inferred by Dr.

Plücker, from the single spectrum of hydrogen gas observed in a Geissler tube of aqueous vapour, coupled with similar experiments in carbonic acid and carbonic oxide, and the vapour of chloride of zinc, which exhibit in succession the spectra of their proximate elements on increasing gradually the intensity of the electric current. The same effect may occasion the phosphorescence of rarefied sulphurous-acid gas, when the electric current after traversing it for a short time is suddenly stopped. Sir Humphry Davy has indeed shown that the combustion of sulphur produces luminous effects, even in air of the greatest possible tenuity. Other combustible elements (as originally pointed out by Mr. Brayley) may enjoy the same property equally with sulphur; and as pyrophoric lead in air and pulverized antimony in chlorine gas exhibit spontaneous inflammation, and even iron, like charcoal, supports its own combustion, it appears not improbable that the whole of the elements of a meteoric surface, dissociated from oxygen by the violence of the heat, are scattered in a vaporous condition around the path of a meteor, and glow with gradual recombustion after its departure. A *rekindling* of the streak after the passage of a shooting-star, and the flame which has occasionally been observed both in shooting-stars and in large fireballs to retreat along the course from the point of greatest expansion, appears to favour this explanation.

Fireballs, like the following class of shooting stars, frequently appear in groups, although not in such numbers as the smaller kind of meteors. The following are remarkable epochs for their annual return. The 2nd of January; 29th of July; 3rd of August, and the 9th to the 12th of August; the 5th to the 14th of November; and 5th to 11th of December. (R. P. Greg.)

In 1727 shooting-stars were proposed to the Royal Society, by Mr. G. Lynn, for the geographical determination of longitudes, with the remark that these had never appeared to him below the clouds, and that their height was probably as great as that calculated by Edmund Halley, for the great meteor of 1719. In 1798, two students, Benzenberg and Brandes, in the German university of Göttingen, attempted the problem proposed by Mr. Lynn, to determine their heights and velocities. Observing in April from a base of five English miles, and in September from a base of ten English miles apart, the average hourly frequency of their observations, and again of those undertaken in 1823 and 1824 (before the periodicities of August and November were suspected), are shown by the table following:—

TABLE III *a*.

Date.	Place.	Description.	Observers.
1798	Göttingen . .	Per hour—10 meters . .	Brandes.
1798	Göttingen . .	Per hour—6 meteors . .	Benzenberg.
1823	Breslau, &c. . .	Each observer, per hour—5 meteors.	Brandes and colleagues.
1824	Brussels, &c. . .	Each observer, per hour—11 meteors.	M. Quetelet and colleagues.

TABLE III *b*.

Date.	Place.	Description.	Observer.
Aug. 10,			
1831	Barbadoes	Many fiery meteors.	
1833	Great Malvern	Numerous cometic fragments.	
1834	Delaware, U.S.	Unusual number of meteors.	
1835	New York, U.S.	Meteors very frequent.	
1836	The same	The same.	
1837	Paris	107 meteors counted in an hour.	M. Arago, jun.
1838	Geneva	Seven hours, 371 meteors	Dr. J. F. Wartman, and Mr. F. Cooper.
1839	Newhaven, U.S.	Three hours, 491 meteors	Prof. E. C. Herrick.
1842	Allahabad	In three hours, 60 meteors	Capt. Shortrede.
1844	Hamburgh	Per hour, 33 meteors	Dr. Jul. Schmidt.
1845	The same	Per hour, 29 meteors	Dr. J. Schmidt.
1846	Newhaven, U.S.	In two hours, 47 meteors	Mr. E. C. Herrick.
1847	Aix-la-Chapelle	In forty minutes, 28 meteors	Prof. Heis.
1849	The same	Five hours, 254 meteors	Prof. Heis.
1850	Hamburgh	Per hour, 30 meteors	Dr. J. Schmidt.
1852	Zurich	47 meteors per hour	Dr. R. Wolf.
1853	The same	19 meteors per hour	Dr. R. Wolf.
1854	The same	28 meteors per hour	Dr. R. Wolf.
1855	The same	32 meteors per hour	Dr. R. Wolf.

It appears by the succeeding table, that a remarkable numerical intensity has occurred annually upon the 10th of August, since the time when attention was directed to these observations. In 1762, Musschenbroek ascribed the prevalence in Belgium of August shooting-stars to summer exhalations of sulphur from the earth. This theory received support by the results ultimately obtained by Brandes and Benzenberg, which included an ascent, like that of a rocket, in the instance of a single shooting-star. The very same points of commencement and disappearance of a shooting-star, cannot in fact be observed at two widely separated stations. Nevertheless, the straight line which intersects mathematically all the four recorded lines of sight in such observations as those of Benzenberg and Brandes is a determinate trajectory of the meteor; but corrections of a single degree applied to the observations transversely to the calculated trajectory may so lower its termination (or elevate the commencement), as to convert an apparently ascending into a really descending flight of the meteor. On these principles Bessel in 1833 assigned *limits of probable error* to the calculated results of Brandes and Benzenberg. The before-mentioned result was disproved, and the difficulty of ascending meteors is removed apparently for ever from the path of a cosmical theory of their origin. The observations of Benzenberg and Brandes, as well as those more recently undertaken, assign variable heights from 20 to 100 miles above the surface of the earth for their disappearance, and 15 to 40 miles a second for the limits of their velocity.

The storm of stars observed by Humboldt and Bonpland, at Cumana, the 12th-13th November, 1799; and the recurrence of the identical ienomenon in 1833 in North America, led Professor Denison lmsted, of New York, to compare observations of six successive years, 31-36; and to propose, for the theory of the evident periodicity of e storm, the possible passage of the earth at this juncture through e outskirts of a zone of asteroids, composing the disc of the zodiacal ght. Increase and decrease of the phenomenon in successive years compared to the yearly and four-yearly returns of eclipses of the ın. To test the asteroidal theory of Professor Olmsted, Dr. Wartman, f the Observatory at Geneva, watched throughout the whole of the ollowing epochal night (1837), in the cloudy air of that season, r the descent beneath the clouds of a single aerolitic particle, without uccess, although the shower was reported to him to have been seen on e same night at other more favoured localities. Subsequently to the emarks of Musschenbroek before cited, T. Marie Ign. Forster, in ngland, drew attention to the storm of shooting-stars, August 10th, 811, and to the records of his father on their general prevalence n August. The same remark was made by Dr. Burney, in 1820, on he meteorological records of several preceding years, made at the oyal Academy of Gosport; and in 1827, Mr. T. Forster published rom a MS. preserved in the library of Corp. Christ. College, Cambridge (the work of a monk in the preceding century), a "Calendar f Natural Phenomena." In this copy, the words "stellibund" and 'meteorode" distinguish the 10th and 18th of August as in the original MS., and are the embodiment of a Roman Catholic tradition, that t. Lawrence, on the anniversary of his martyrdom, the 10th of August, heds yearly burning tears; and perhaps of the astonishment created y the great meteor of August the 18th, 1783. M. Quetelet, in December, 1836, aware of the unconcealed periodicity of the November hower, asked of the Academy of Sciences of Paris, if the second week n August were not like that of November, an annual epoch of the ecurrence of shooting-stars. The elder son of M. Arago, with one ssistant, at Paris, counted in a single hour on the following 10th of August, 107 shooting-stars. The conjecture of M. Quetelet was thus onfirmed, and it has not since deceived the yearly expectations of bservers. Simultaneously with M. Quetelet, Mr. E. C. Herrick, of Newhaven (Connecticut), following the views of Professor Olmsted, ndicated the probability of a cosmical phenomenon in August, and with great industry collected instances, where an eruption of Vesuvius, a hurricane at Barbadoes, and other accidental circumstances had led bservers to record the 10th of August, in all parts of the globe, as emarkable for shooting-stars. The researches of Professor Herrick ad the merit of pointing out, unassisted, *the day* of the return, which as not since required correction. Secondary to periodicity, an argument for the cosmical origin of these showers is found in their fixed ranographical region of emanation. Like the shadows from a straight andle-shade, the whole of the parallel paths appear to diverge from a single point, which has its place unchanged among the stars during the whole continuance of the shower. In November, the radiant point rises above the horizon at midnight, in the Lion; in August it belongs to the circumpolar stars, in AR 50°, N. Decl$^{n.}$ 51°, and were the relative velocities of the particles through the earth's atmosphere exactly determined, the eliptical dimensions of the cosmical zones about the sun might be readily calculated, and their periodic time concluded. A similar stream, with a radiant in corona, is noticed in the mornings of April 21st; and the 2nd of January, the 29th of July, 19th of October, and 7th of December, have been named by Messrs. Quetelet and Julius Schmidt as prolific in shooting-stars. The different features of shooting-stars, like those of fireballs, are not numerous, nor do they appear to militate against the theory of their small-planetary or asteroidal character.

Since the great fall of stones at Sienna, in Italy, in 1794, followed by others at Wold-cottage, Salés, and Benares, and at length by that of Aigle, no doubt remained of the facts which required scientific explanation; and copious collections of examples are now found in the largest mineralogical museums. Our own national collection contains 111 specimens of stones, and 79 masses of iron, known or reputed to have fallen from the air; and differs in this respect by only 18 to 25 localities from the large original collection of these minerals at Vienna. The falls of aerolites are attended by luminous phenomena in no way distinguishable from the class of larger fireballs. Although accounts are not so precise as to justify the conclusion of their identity, a review of numerous observations since the great fall of Sienna raises a strong presumption that the light of silent and detonationg fireballs is caused by the flight of small aerolites with high velocity towards the earth.

Table of Aerolitic Falls attended by Fireballs since 1794.

TABLE IV.

Date.	Place.	Fireball.	Aerolites.
1794. June 16, 9 p.m.	Sienna, Italy.	Bright meteor and stationary cloud. Many concussions. Clear sky.	After the reports fell many stones, with prolonged noise. 7 lbs., &c. Many feet deep into the earth.
1798. March 12, 7 p.m.	Salés, France.	Large fireball, with sparks. Long train. Detonated.	A stone fell with noise. 25 lbs. 1½ ft. deep.
1798. Dec. 13, 8 p.m.	Benares, India.	Fireball, as large as full moon; broke into pieces. Clear sky. Detonated.	Many stones fell, 10 lbs., &c., 6 in. deep.
1803. April 26, 1.30 p.m.	Aigle, France.	Large fireball over Alençon, Falaise, Caen. Stationary cloud and concussions at Aigle.	2,500 stones fell. 18 lbs., &c. Too hot to touch.

Table IV.—(*continued*).

Date.	Place.	Fireball.	Aerolites.
1807. Dec. 14, 6.45 a.m.	Weston, Connecticut.	Large fireball; rose and fell; burst and detonated. Velocity, 3 miles per second.	Stones fell at three points. 35 lbs., &c.
1810. Nov. 23, 1 p.m.	Charsonville, France.	Large fireball; disappeared 20 miles high. (Dutrochet.) Three concussions heard.	Two stones fell. 40 lbs. and 20 lbs.
1812. April 15, 4 p.m.	Erxleben, Saxony.	Large fireball; seen at Dessau.	A stone fell with great noise. 4½ lbs.
1820. July 12, 5.30 p.m.	Lixna, Dunaberg, Russia.	Large and brilliant fireball.	Stones fell at three places with loud concussions.
1821. June 15, 3 p.m.	Juvenas, Languedoc.	Considerable fireball seen.	After an interval fell a stone with loud concussions. 220 lbs. 5½ ft. deep.
1822. June 3, 8 p.m.	Angus, France.	Fine shooting-star, seen at Poictiers. Luminous streak contorted itself; remained 15 minutes.	Small stones fell after a loud report. 2 lbs., &c. Cold when they fell.
1833. Nov. 25, 6.30 p.m.	Blansko, Moravia.	Brilliant fireball.	Three stones fell after a noise like thunder.
1836. Dec. 11, 11.30 p.m.	Macao, Brazil.	Fireball of extraordinary size and brilliance. Exploded with loud reports.	Very extensive shower of stones fell. 80 lbs., &c.
1838. Oct. 13, 9.30 p.m.	Bokkeveld, Cape of Good Hope.	Silvery fireball. Detonations like three cannon-shots.	Many stones fell, and broke in pieces. 10 lbs., &c.
1847. July 14, 3.30 p.m.	Braunau, Bohemia.	Fireball and cloud. Two red streaks descended to the ground. Two concussions heard.	After an enduring report fell 2 iron masses, 1½ miles asunder. 42 lbs. and 30 lbs.
1851. April 17, 8 p.m.	Gütersloh, Westphalia.	Fireball, like full moon; with train. Burst into sparks 45° above the horizon. Detonations in 2 minutes.	In 10 minutes an enduring report, and 2 stones fell. 2 lbs. and ¾ lb.
1852. Sep. 4, by day.	Mezo-Madras, Transylvania.	Fireball, with a flash like lightning; broke and detonated.	Long after the thunder fell many stones.
1857. Oct. 1, by day.	Les Ormes, France.	Large fireball.	Stones fell. ½ lb., &c.

It appears from these accounts that fireballs scattering aerolites produce an audible concussion before the precipitation of the stones upon the ground. The volume of compressed air transported in front of a meteorite is perhaps sufficient by its liberation to convey an audible report from the almost empty spaces in which the concussions occur, but the obstruction of the denser air delays the catastrophe of the meteor's fall upon the earth until the thunderclap has already announced the blow of its arrival in the atmosphere. In the catalogue of 1400 meteors collected by Mr. Greg, 22 per cent. were attended by aerolitic falls. From various combinations of velocity and dimensions the disappearance of so large a proportion of fireballs may be explained by dissipation in the air; and of some, by loss upon the surface of the earth.

Connected with this view of the origin of fireballs is the mineralogical examination of aerolites and aerosiderites. The stones of Stannern were in their external features studied by Von Schreibers, and Widmanstätten developed crystalline structure by etching polished surfaces of meteoric iron; Rose, Wöhler, and other chemists have analysed a large number both of aerolites and aerosiderites; and most recently Professor Maskelyne has been occupied in a minute study of their ingredients in thin sections of their substance, and by crystallographic measurements of some of their constituent minerals. It follows from the analyses, and from these microscopical investigations, that olivines, varieties of augite, eustatite, anorthite, and other as yet undetermined silicates, besides nickeliferous iron, metallic and pyritic, form the materials of the stones, and are mingled in crystals or spherules in a tufaceous but crystalline magma. Their structure, however, is not paralleled by any known geological rocks. Schreibersite, a singular phosphide of iron and nickel, is found in these stones, as elastic yellowish crystalline laminæ, and also appears, by its resistance to the action of acids, to assist in the production of the Widmanstättian figures seen in the nickel-iron alloy. It points to a scarcity of oxygen in the native region of the stones. Carbon and many metals, but no new element, are found among the mineral constituents. A hydrocarbon in the stones of Alais, Kaba, and Bokkeveld, but no certain proof of organic remains have been hitherto detected. The black enamel-like glaze which envelops perfect stones is proof of sudden and momentary exposure to flame of intense heat, since the time when the meteorites were broken from their native rocks, and hurled upon the earth. The lunar "ballistic" theory of their origin is exposed to the objection of enormous volcanic activity necessary for a single accurate aim with aerolitic velocities, no doubt greatly exceeding those of circumterrestrial orbits. Such volcanic action is not perceived in the neighbourhood of the centre of the moon's visible disc. Their course is therefore more probably of a planetary nature and orbitual about the sun.

The crepuscular atmosphere in which meteors are luminous, has been called by M. Quetelet the stable atmosphere, distinguished by dryness and immutability from the unstable atmosphere below, in which rain is prepared, and storms burst forth and commingle the parts. Positive electricity he conjectures to reside upon the lower, and negative electricity upon the upper portions of this lofty atmosphere, which by librations about the centre of its figure may cause the known magnetic sturbances and variations of the needle. At the base of this region . Quetelet supposes the aurora to have its place; banks and arches of ht being formed horizontally near its lowest confines and streamers m these shooting upwards, to relieve from time to time the varying sions in the stratum. In this view, negative horizontal currents, lowing the sun, explain the southward drift of the auroral arch, and minous discharges towards the upward pole of the dipping-needle casion a canopy of converging beams arising from the arch. Dr. ücker has indeed shown that in gases moderately dilated, luminous rrents obey the rotatory influence of the magnet, but that in extremely re gas the discharge is stationary and confined to the direction of the gnetic lines of force.

The phenomena of luminous meteors and the aurora are thus ied to one another by their appearance at the outer confines of the ;, and well directed observations of their particulars are a source of struction at once to the astronomer and the meteorologist. But in r present uncertainty of the material, and of the physical and chanical constitution of these extreme boundaries of air, projects of servation must aim at results very difficult to anticipate or to define, d the words of Benzenberg himself still ring in our ears, "Such uestion will have time."

[A. S. H.]

ANNUAL MEETING,

Friday, May 1, 1863.

THE DUKE OF NORTHUMBERLAND, K.G. F.R.S. President,
in the Chair.

The Annual Report of the Committee of Visitors for the year 62 was read and adopted.

The amount of Contributions from Members and Subscribers in 62 amounted to £3079. 13*s.*; the Receipts for Subscriptions to ectures were £560. 14*s.*; the total Income for the year amounted £4630. 8*s.* 1*d.*

On Dec. 31, 1862, the Funded Property was £29,341. 2*s.* 2*d.*; d the Balance at the Bankers, £804. 3*s.* 4*d.*, with Six Exchequer ills of £100 each.

A List of Books Presented accompanies the Report, amounting in umber to 161 volumes; making, with those Purchased by the

Managers and Patrons, a total of about 558 volumes (including Periodicals) added to the Library in the Year.

Sixty-two Lectures and Twenty-one Evening Discourses were delivered during the year 1862.

Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and to Professor Faraday and the other Professors, for their services to the Institution during the past year.

The Special Thanks of the Members were voted to Sir Henry Holland, Bart. Sir Roderick I. Murchison, K.C.B. and Samuel Reynolds Solly, Esq, for their Donations for the purchase of Scientific Apparatus.

The following Gentlemen were unanimously elected as Officers for the ensuing year :—

PRESIDENT—The Duke of Northumberland, K.G. F.R.S.
TREASURER—William Pole, Esq. M.A. F.R.S.
SECRETARY—Henry Bence Jones, M.A. M.D. F.R.S.

MANAGERS.

Sir William George Armstrong, F.R.S.
The Rev. John Barlow, M.A. F.R.S.
Sir John Peter Boileau, Bart. F.R.S.
George Busk, Esq. F.R.C.S. F.R.S.
George Dodd, Esq. F.S.A.
Sir George Everest, C.B. F.R.S.
John Peter Gassiot, Esq. F.R.S.
Sir Henry Holland, Bart. M.D. D.C.L. F.R.S.
Sir Roderick I. Murchison, K.C.B. D.C.L. F.R.S.
James Nasmyth, Esq.
William Frederick Pollock, Esq. M.A.
Robert P. Roupell, Esq. M.A. Q.C.
The Lord Wensleydale.
Charles Wheatstone, Esq. D.C.L. F.R.S.
Colonel Philip James Yorke, F.R.S.

VISITORS.

Hon. and Rev. Samuel Best.
George J. Bosanquet, Esq.
Archibald Boyd, Esq.
John Watkins Brett, Esq.
Bernard Edward Brodhurst, Esq.
John Charles Burgoyne, Esq.
Montague Chambers, Esq. Q.C.
George Frederick Chambers, Esq.
Christopher Darby Griffith, Esq. M.P.
Captain Frederick Gaussen.
Kenneth Macaulay, Esq. M.P. Q.C.
Edmund Packe, Esq.
The Earl of Rosse, F.R.S. Chancellor Univ. Dublin.
The Earl Stanhope, D.C.L. F.R.S. Pres. Soc. Antiq.
George Tomline, Esq. M.P.

WEEKLY EVENING MEETING,

Friday, May 1, 1863.

SIR JOHN PETER BOILEAU, Bart. F.R.S. in the Chair.

JOHN LEIGHTON, Esq. F.S.A. M.R.I.

On Japanese Art—illustrated by Native Examples.

OF all the marvels of Art and Industry collected at the International Exhibition in 1862, none excited greater attention or admiration from the reflective visitor than the contributions of Asia, including as they did the productions of India, Turkey, China, and Japan, and also of a host of islands—the inhabitants of which seem alike gifted with Art powers, indigenous to the soil on which they grow, as the gorgeous plants of the tropics flourish independently of care or culture: I allude particularly to that marvellous perception of form and colour, founded upon the laws of nature, and demonstrable by the aid of science or the rules of art, that seems the heritage of all Asiatics.

To the Dutch we are much indebted for keeping alight the feeble flame, the spark of European intercourse, that has never been allowed to die out, greatly to the benefit of all. Through this channel many things reached the court of the Tycoon, as others found their way, *viâ* the Netherlands, into Europe; yet the Hollander seems to have profited little by the æsthetic lessons of Japan. The *Cabinet Royal de Curiosités* at the Hague, though a great source of attraction to strangers, is certainly not so interesting or instructive as it might be made; scarcely rivalling the *Musée Siebold* at Leyden. In matters of applied art the Dutch have not a refined taste; they have a good school of *genre* in painting, though none of either architecture or ornament.

In contrasting the arts of China and Japan, what strikes one forcibly is the marked difference of labour,—the Japanese aiming to produce the greatest possible effect at the least expenditure of trouble, whilst the Chinese make pains a principal virtue; they toil and spin, but lack inventive power, working from instinct rather than from the dictates of reason,—a fault with all Asiatics, in greater or lesser degree—degrees that seem to reach their climax as they near the coast, and are lost in the great ocean, or are tided over to the numerous islands, there to be modified, translated, and adapted to other wants.

The Japanese court in the International Exhibition, though somewhat crowded, was beautifully arranged by Sir Rutherford Alcock, to whom we are indebted for the collection of objects, as also those admirable volumes, "*The Capital of the Tycoon.*" Would that our envoys in remote corners of the world had done likewise, for I feel sure that in the islands of Formosa, Java, and Ceylon, are an infinity of objects of the rarest interest to Europeans.

The people of Japan, whilst they seek safety in seclusion, seem by no means to be blind to outward influence; to learning from any source: with all their love of feudalism and seclusion, the Japanese appear much more free in thought than their neighbours the Chinese, being a people who, though bound by strong tradition, are ever ready to learn, as many of their arts and manufactures clearly demonstrate. European influence is to be found in their fire-arms and ships; it has taught them linear perspective, as it will many other sciences; in fact, the horses that now shamble in shoes of straw, will gallop in iron, since Japanese chargers *have* been tipped with that metal, in imitation of some steeds that have found their way across the ocean. To teach and be taught ought to be the mission of man, but let *our* teachings be those of peace; let us not, like the Americans, make presents of artillery, and give instruction in its use; if we are to send them engines, let them be fire-engines, to prevent destruction—let element subdue element, or be subjugated to their use—in the locomotive, though I fear the railroad, from natural causes, may be difficult, if not impossible, in Japan.

I commence with Architecture, because building is the primary office of man—construction came before decoration—though one can hardly exist without the other; the man who constructs a deal box produces a pretty ornament, at the same time making a dove-tail, doubly beautiful, because it grows out of the construction; thus construction and decoration go together.

As architects, the Japanese have many difficulties to contend with; they build as their fathers built—not from conservative feeling alone, like the Chinese, but because the elements are against them. Man may raise *up*, but the elements in Japan can raze *down*, earthquakes being of frequent occurrence there, rendering a wooden construction necessary,—buildings that in ordinary hardly rise above the dignity of a Swiss châlet of the most plain proportions: the gabel finals and ridge tiles being, perhaps, the principal features of erections, rarely higher than two stories, with galleries and verandahs—the doors and divisions of rooms composed of sliding-shutters—the whole edifice resting upon a foundation of stone supported upon legs of wood, somewhat as a four-post bedstead stands; this form being best suited to resist concussions caused by the trembling earth.

The temples and gateways are of timber, with massive tent-shaped roofs, like the homes of the Tartars and Chinese, but with many details purely Indian; some of the edifices, as they stand upon their stone bases, reminding one strongly of the Assyrian restorations at Sydenham Palace; indeed, it is very curious to find many types from the ancient Egyptian, Assyrian, and Greek, perpetuated in the 'these remarkable people; how they came to be embalmed in art of the present day it would require deep research to a subject for the antiquarian, who looks backward, rather man of science who looks forward: though men of the past re alike teach the present.

y outlines A is taken from a tomb, hundreds of which are to l in their cemeteries; a treatment of the sacred bean and common in ancient Egypt, as odia, the great seat of the Bud-th. Figs. 1 and 3 are purely The Greek fret and echinus, or tongue moulding, are both used and Japan, key patterns being t popular. Fig. 2, in which re united in a bud, is also com-ugh more Assyrian than either bers. These forms, with many renderings of the Anthemion, comprise their principal an-ies.

A

I.

II.

III.

orkers in stone, the Japanese are decidedly clever; though e of the foundations will not permit of nine-storied pagodas, wonders with the material; having a timber architecture—ate wood in stone (instead of stone in wood and plaster, as pt to do); as shown in a photograph of a semicircular bridge —the struts, planks, mortices, and all being as if of timber,

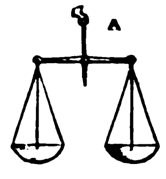
ieir architecture and sculpture devoted to the purposes of the Japanese seek the aid of symmetry ignity, a majesty obtainable by no other rigidity carried to the greatest extent orks of the ancient Egyptians, though ks and Romans were well aware of its In ornamenting their secular objects, iese seem studiously to avoid exact i or a counterpart of lines, or, if they i, do all they can by means of decoration to destroy an exact or repetition of any portion. All other nations seek symmetry ple, save these people and the Chinese, though the latter in gree.

A

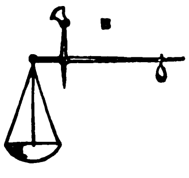
B

iy of illustration, I may say they shun an equality of parts, or appearance of an equal-irts, weighing with the B instead of the scales ce with them is not even-and, though they give i another way, they do by diametrical division. or repetition of parts,

A

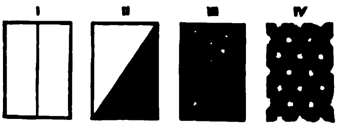


B



has been considered the acme of architectural and ornamental art, though not so of pictorial art, which must be more varied, and is, save in exceptional cases, where the high position or centre is appropriated to a deity or hero; in such the pictorial is subservient to the decorative.

Diametrical division the Japanese dislike. Fig. 1 has not variety enough for them; they do all they can to get rid of a vacuum, as in Fig. 2, following the precedent of Nature, who never repeats herself either in spangling the skies with stars or the earth with daisies of the field, as in Fig. 3. Diapers and conventionalized forms, as in Fig. 4, are not so popular with them as with us, who appreciate their value to break up surfaces and lead the eye to measure distances.



The arts of Japan may be said, in an eminent degree, to depend upon the picturesque, though rarely to reach the pictorial, that is to say, they never produce a picture, because the principal element of pictorial art is wanting; light and shade—a cloak with us that covers a multitude of sins—they know not of. Art of the highest kind may, and often does, exist without chiaroscuro; for instance, the divine compositions of Flaxman owe none of their world-wide fame to shade or colour. In their works may be observed the effects of light and dark, somewhat akin to that of chiaroscuro, rendered with much truth to Nature, and a dignified simplicity that many of our artists would find it difficult to imitate.

In Japan we are told there are no academies of Art, nor have the artists any status above that of the cunning craftsman; a hopeful thing, perhaps, for the future—Nature's students standing the less chance of being fêted, lionized, or spoiled.

For powers of drawing, native examples vary greatly, though all are deeply interesting to the art-student, who may learn from the humblest specimens. The larger coloured examples being very remarkable for a certain typical rendering of the human face divine, not to be found in smaller engravings or in Nature, a droll sort of leer pervading all with an Egyptian uniformity; though, unlike the ancient examples from that nation, perspective has taught the Japanese artist to draw faces in three-quarter view, and so vain does he appear of the power as rarely to deviate from it. Apart from defective drawing of heads, hands, and feet, the examples are very interesting, showing much good proportion, action, and drawing of drapery; whilst in colour they are very suggestive, some of the hues and patterns being handsome in the extreme.

The landscapes are very quaint, aërial perspective seeming beyond their powers, except in one or two cases where white mists have been attempted, as also rain, fog, and snow. In depicting clouds the Japanese artist seems sorely puzzled—the tinted ribbons they stretch across the heavens looking like labels for inscriptions rather than floating vapours.

The smaller samples, cut from their books, are full of fun and first-rate drawing, being quite in spirit equal to anything done here in the present day; ay, and done with few lines and marvellously little effort. Many of them have been engraved in Sir Rutherford's recent work; the larger efforts in colours show what the Japanese think of us and our ladies; crinoline of the amplest being faithfully depicted, as also beards, chimney-pot hats, and other peculiarities of the Western race. One of a lady in wide hoops, mounted on the wrong side of a native charger, is inexpressibly droll, showing what we may expect to behold if ever that sketch-book, so freely used last season by a member of the two-sworded embassy, should be published. Then shall we see London society as others see us, though I give the preference to native art on native subjects, particularly where there is action; for curiously some of the best are figures in movement—porters lifting, balancing, and carrying their loads; an acrobat poising his companion, a juggler; street-boys full of mischief or weeping over broken dishes; mechanics at work; ladies bathing; and indeed a hundred-and-one phases of social and animal life: the lower portion of the creation are finely rendered, particularly birds in flight, ducks, geese, and cranes being hit off with wonderful precision by no ordinary marksman.

A, C, and D, are from the smaller works; B, a typical mouth, from the larger.

In composition they are good, two or more figures uniting in the production of admirable lines; though, like the early artists of other nations, the Japanese make their point of sight very high, all figures being as if looked down upon.

In colour, as a nation, they are very judicious, rarely producing discords, either in their attempts at picture-making or applied art—a thing that can hardly be said of either English or French. The British manufacturers, traders, and 'people in general, have but little love of colour, though her painters and architects appreciate it highly. In France this is *au contraire—her* manufacturers and traders claim colour as an inheritance, but her painters disregard it, or place it as a minor accomplishment; the French school being one of form rather than colour.

Without attempting to solve this seeming paradox, I would here make note of another, and ask how it is fine styles of architecture and ornament seem, with the exception of ancient Greek art, never to have flourished with a perfect knowledge of drawing the human figure. With the revival of painting in Italy purity of taste in matters of design died out. We know that Raphael painted the Loggia of the Vatican, but of what monstrosities and incongruities is it not composed! I just mention this by the way as a warning against the Renaissance, and particularly the French version of it, that finds favour in certain quarters to the exclusion of better things; whilst in India, Turkey, and Japan, we have an inexhaustible well of art, pure and undefiled, most eloquent in its teachings; an art that was appreciated by the great masters of mediæval times, all styles bearing evidence of the eastern forms and colours brought overland by the pilgrims of the Cross.

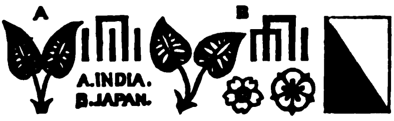
With the spread of the Reformed Religion colour and design died out, being voted pagan and popish; antique figure-drawing and classic conceits taking their place, until light, shade, and pictorial effect reached its zenith in Rembrandt—the great genius of Holland—where black and white have triumphed over colour, form, and design. I think we may say that conventional art, including architecture and sculpture, was never lower than when the great school of *genre* and imitative art flourished.

But to the East, where colour reaches its climax, as it tans the skin and renders man fit to support primitive hues, the love of which perhaps is to be found most highly in the negro, though in the Hindoo must be sought the subtle appreciation of it. Leslie has somewhere said, the only perfect specimen of colour he had seen was in a Chinese picture. What he would have said to these of Japan we can only conjecture,—colour with perspective, and shade nowhere!

We now come to sculpture, of which there is little evidence to show, though the Japanese are cunning carvers in stone, modellers, and metal workers, having a veritable passion for relief in everything; even their painted lacquer boxes are raised, the animals being very faithfully depicted, showing how they catch the salient peculiarities of Nature in every case, be it in the beautiful miniature carving of an egg-shell—containing figures that must have been sculptured through the broken chinks; or a draught-ox reposing; bagatelles, replete with art-feeling and finish—the underlying surfaces being truly rendered: indeed the way the animal's legs are doubled up and disposed of is quite a study. Space being limited, I must content myself with the poetical combination of the whole animal kingdom in a dragon-vase, upon which the monster is wreathing in and out of thunder-clouds, a bolt in either claw; a magnificent type of the terrible power of electricity bursting its bounds. I do not hesitate to say that had this piece of poetry in bronze been worked on a grand scale, and placed on a pedestal, it would have found worshippers even here, so largely and grandly is it treated. A thing I can hardly say of a very large figure-idol, of which I have seen a very small photograph. The proportions were good and pleasing, a calm serenity pervading the whole, without that combination of monstrous elements so common in Indian deities, to which it bore some resemblance.

Having disposed of the higher elements of genius in Japan, we now those phases of applied art by which a people become known ture historian of art.

t applied to manufactures, the Japanese stand very high, their y of thought being remarkable; rarely repeating anything by iumb, or copying without some modifications. How different hinese, where a tailor will reproduce a garment for you stitch ı, patches included; or porcelain fabricants copy china vases, rivets and all, effects and defects likewise. In their manu- they studiously avoid symmetry (as I said before), aim to ı the greatest variety in the smallest space, and, whilst they onalize, worship Nature in the utmost; some of their ways arvellously droll to us. This I will illustrate in the decoration ' common box, brought me by Sir R. Alcock. You will per- ı lid of the article being square offended the Japanese eye, as it ıy other eye properly constituted; decoration being sought, a rawn across the article, not horizontally or vertically, as any tion would have done, but diagonally, because it produced the rariety at the cheapest ng parti-coloured, the surface of the lacquer gain broken up with ' stamps, disposed in t irregular manner). These devices I wn on a larger scale, and contrasted them with figures from ı), showing how types begin to differ; forms that in Japan are l, become in India more symmetrical, and in Europe quite so.



, again, a book-cover, stamped, shows the same principle, being all over with representations of coins, relieved here and there b of gold (like the tin-foil in a government stamp), and a g of the like metal. Variety is charming, but unity is hand- l respectable. Europe adores unity, but the far East worships Reason is sorely puzzled to make choice.

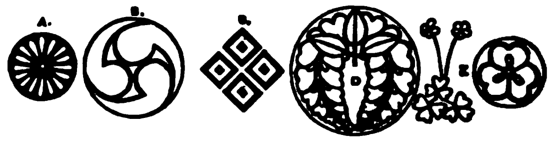
escribe all the varieties of Japanese art would require much space; thus we must content us with a few samples embody- same principles. Witness the charming variety of a little mark the different sizes of the drawers, the largest lowest to ght; the handles formed of an irregular figure, of different metals. See the material it is composed of (tortoiseshell), varied surface, on which are painted subjects in outline, en- gures in relief, but never in the middle of the spaces they eing of strange forms overlapping one another. I think these ould like to do without the centre of gravity, an idea per- endered by their familiarity with earthquakes.

inic eruptions and grand storms, doubtless, have had much to ie perfecting that terrible myth the dragon, who, though never been often heard, being finely rendered, as are most of the ıd vegetable wonders depicted upon Japanese ware, all kinds of creatures being pressed into the service, and made to meet the wants of the article decorated. The manner in which flowers and birds are bent and twisted over surfaces is highly curious, as also the way they suggest ideas for shapes—sometimes so true to Nature as to make one wonder at the draughtman's skill, whilst in others so highly conventionalized are they as to make one doubt the authority. Hawthorn, bamboo, and rush are very common, as also cranes and tortoises, and landscapes touched in golden outlines.

Pattern upon pattern, and form upon form, is by no means uncommon in Eastern art, but the way circular patches are placed upon frets and grounds is, I think, peculiar to China and Japan.

Small round ornaments are very popular in Japan, doubtless from the resemblance they bear to the crests or badges of Daimios—forms defended by law; hence their popularity amongst the people in general, as at home lions rampant and dragons displayed may be bought of every stationer.

It is curious that all those badges (Figs. A, B, C, D, E), or nearly all, should be derived from floral ornaments, Japanese heralds being guided by some principle—for in a first book for children, I find a popular badge in its conventional form with the plant it is derived from, E. A red sun, or rather a red ball, as we should call it, is the emblem of the empire of Japan, also to be seen in the book, and upon an official document sent to the British legation at Yeddo—showing, likewise, the insignia or crests borne or carried by the Yakoneens or retainers of Daimios—guards in charge of our ministers to the court of the Tycoon.



From books to paper and print, the transition is not great. With a few remarks on engraving, printing, and paper-making, I will close my list.

As engravers upon wood and metal, the Chinese are known to have been skilled long before civilization had dawned upon England, or even Europe had dreamed of tomes in black letter; but few, a year ago, would have ventured, I think, to claim the priority of colour-printing for Japan; yet this may be the case; for in no instance do their specimens bear evidence of having been copied from anything done in the Western World, being hand proofs, worked in flat tints, without a press; secondaries or tertiaries in very few instances being produced by working colour upon colour, as with us, who use no outline to indicate form.

Truly may we say there is nothing new under the sun, and particularly under the red sun of Japan; for here we have two recent ventions superseded, one being graduated or rainbow-printing, and e other some method by which blocks or prints can be reduced.

If the printing excites our wonder, what shall we say to the paper, r certainly we have nothing like that article, which plays so important part in Japanese life, serving a hundred purposes unknown to us, eeping out the wind and weather from man and mansion, the windows nd coats alike being made of that substance, which bears little re-emblance to the rag papers of other parts—our own included. We nport materials for paper manufacture from Japan, but not such as native would use: the bark of the paper mulberry being much ougher than refuse rags, he wisely retains the former, but vends the tter. The toughness and pliability of paper from Japan is surpris-ng, especially in the thinner sorts, as, when held up to the light, it ppears full of holes, the woolly fibre of which it is composed being istinctly seen. It is very light and absorbent, printer's ink penetrat-ng the fabric, which, from that cause, has to be made double when ound up in a volume. How unlike our straw paper, so unpleasantly rittle, and disagreeably dirty when printed upon, ink merely lying on he surface: making one despair of seeing straw paper take the place f the finest morocco leather, like the wonderful samples shown in the xhibition, 1862, or do duty for the most delicate cambric, in the hape of pocket-handkerchiefs, as paper does in Niphon.

Verily the Japanese are a clever people; and earnestly do I hope hey may be richer and happier for their intercourse with Europe, hough I doubt it, in some respects. A people so sensitive will copy any of our defects, as the natives of British India have done, degrad-ng themselves to meet the wants of European taste, as we all saw in he Indian department of the late Exhibition, which contained a great eal of misapplied ornament, in the shape of Louis Quatorze carpets, npossible chairs, and tables the very tops of which were richly, but nappropriately, carved; some of the presentation plate being abomina-ble, as Dr. Forbes Watson fully admitted, when he consulted me as to he objects of art he should send out as aids to instruction in the native chools. I advised him, as I would advise art missionaries to Japan, ot to propose or dictate to a people our superiors in so many things; o supply them with objects of science rather than objects of art; teach hem perspective, the laws of proportion, and of colour (if you can); upply them with photographs, but let Nature teach *them* art—teach ot until you have learned.

With these words I would have concluded these humble opinions, ut feel I have yet another remark to make; namely, one of warning o collectors of articles from Japan, to be careful in the selection of bjects—where all are quaint and curious, quality sometimes escapes bservation; and, I would here make known the regret I feel that we ave no collection of the best products of these remarkable people, not cabinet of curiosities alone, but a gathering of the ordinary articles of he country, selected by some men of judgment and taste, acquainted ith our wants, who could explain things and their uses. A knowledge of the ingenious aids to education, books, toys, and instruments, apart from their processes and machines, would be the inheritance of a large estate, an estate that we shall doubtless see the fertility of when we can find, in central Paris, a *Musée Japonais*, that we may copy secondhand, as we usually do.

I am informed by Sir Rutherford Alcock, to whom I am indebted for many facts, that a really good collection of works, illustrating the arts and industry of Japan, could be obtained for one thousand pounds, and I would ask what that sum regards to a nation that makes the world its market-place, and England its home?

[J. L.]

GENERAL MONTHLY MEETING,

Monday, May 4, 1863.

WILLIAM POLE, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Chairman announced, that His Grace the President had nominated the following Vice-Presidents, for the ensuing year:—

Sir William G. Armstrong, F.R.S.
The Rev. John Barlow, M.A. F.R.S.
Sir Henry Holland, Bart. M.D. D.C.L. F.R.S.
Sir Roderick I. Murchison, K.C.B. D.C.L. F.R.S.
The Lord Wensleydale.
William Pole, Esq. M.A. F.R.S. *Treasurer.*

John Graham, M.D.
Cosmo Richard Howard, Esq.

were *elected* Members of the Royal Institution.

William Hartree, Esq.
Arthur Staveley Hill, Esq.
Leveson Vernon Harcourt, Esq.
Henry Lainson, Esq.
Paul Julius Reuter, Esq.
George S. Trower, Esq.

were *admitted* Members of the Royal Institution.

The Managers reported, That Sir RODERICK I. MURCHISON, in conformity with his announcement at the last General Monthly Meeting, had presented to the Institution the sum of £20 for the purchase of Scientific Apparatus.*

They further reported that the Secretary had received the following letter from Samuel Reynolds Solly, Esq. F.R.S. M.R.I.:—

"Dear Sir, 10, *Manchester Square, April* 17, 1863.

"I beg to enclose you a cheque for £20, which I will thank you to give to the Treasurer of the Royal Institution, and to state, that I intend paying the same sum every year during my life; my wish being, that the money be applied in the same way as the donation of £40 by Sir Henry Holland.

"I remain, very faithfully yours,
"S. R. Solly.

"Henry Bence Jones, M.D."
&c. &c.

The Treasurer announced, That Sir Henry Holland, Bart. had again presented the sum of Forty Pounds, being his Fifth Annual Donation for the purchase of Scientific Apparatus.†

The following Professors were elected:—

William Thomas Brande, Esq. D.C.L. F.R.S. Hon. Professor of Chemistry.

John Tyndall, Esq. F.R.S. Professor of Natural Philosophy.

Edward Frankland, Esq. Ph.D. F.R.S. was elected Professor of Chemistry.

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Astronomical Society, Royal—Monthly Notices, March, 1863. 8vo.
British Meteorological Society—Proceedings, Nos. 5, 6. 8vo. 1863.
Chemical Society—Quarterly Journal, New Series, No. 4. 8vo. 1863.
Civil Engineers, Institution of—Proceedings, April, 1863. 8vo.
Dircks, Henry, Esq. (*the Author*)—Contribution towards a History of Electro-Metallurgy. 16to. 1863.
Editors—Artizan for April, 1863. 4to.
Athenæum for April, 1863. 4to.
Chemical News for April, 1863. 4to.
Engineer for April, 1863. fol.
Horological Journal, No. 56. 8vo. 1863.
Journal of Gas-Lighting for April, 1863. 4to.
Mechanics' Magazine for April, 1863. 8vo.
Medical Circular for April, 1863. 8vo.
Practical Mechanics' Journal for April, 1863. 4to.
St. James's Medley for May, 1863.
Technologist for April, 1863. 8vo.
Franklin Institute of Pennsylvania—Journal, No. 447. 8vo. 1863.

---

* See p. 73.

† See Annual Meeting, p. 98.

Geographical Society, Royal—Proceedings, Vol. VII. No. 2. 8vo. 1863.
Geological Institute, Vienna—Jahrbuch, Band XII. No. 4. 4to. 1862.
Horticultural Society, Royal—Proceedings, 1863. No. 4. 8vo.
Linnean Society—Transactions, Vol. XXIII. Part 3; Vol. XXIV. Part 1. 4to. 1862–3.
Manchester Literary and Philosophical Society—Proceedings, 1862–3. Nos. 1–12. 8vo.
Mechanical Engineers, Institution of—Proceedings, 1862. Part 3. 8vo. 1863.
Medico-Chirurgical Society, Royal—Proceedings, Vol. IV. No. 3. 8vo. 1863.
Newton, Messrs.—London Journal (New Series) for April, 1863. 8vo.
Petermann, A. Esq. (*the Editor*)—Mittheilungen aus dem Gesammtgebiete der Geographie. No. 3. 4to. 1863.
Photographic Society—Journal, No. 132. 8vo. 1863.
Silliman, Professor—American Journal of Science, &c. for April, 1863. 8vo.

WEEKLY EVENING MEETING,

Friday, May 8, 1863.

SIR RODERICK I. MURCHISON, K.C.B. D.C.L. F.R.S. Vice-President, in the Chair.

DR. AUGUSTUS VOELCKER, F.C.S.

CONSULTING CHEMIST OF THE ROYAL AGRICULTURAL SOCIETY OF ENGLAND.

On some Chemical and Physical Properties of Soils, and the Productive Powers of the Soils of England.

IN all fertile soils we find variable quantities of organic matter—ready-formed ammonia, nitric acid, potash, soda, lime, magnesia, oxides of iron, chlorine, phosphoric, sulphuric, and silicic acids; in short, all the mineral matters which are found in the ashes of plants. These minerals, or ash-constituents, it need scarcely be observed, are not merely accidental but essential materials, without a proper supply of which no plant can grow luxuriantly and come to full maturity. In one sense all are equally important; for the absence or deficiency in the soil of one, be it lime or potash, phosphoric or silicic acid, is detrimental to the luxuriant development of the vegetable organism. No one who has given the slightest consideration to this subject will hesitate to give assent to this mineral theory.

It is natural to connect the productiveness of soils with the proportion of ash-constituents of plants which they contain; but although in some cases a soil may be unproductive on account of the absence or deficiency of lime or potash or phosphoric or any other mineral matter which enters into the composition of plants, in the majority of cases the chemical analysis of different soils affords little or no indication of their relative productive powers.

The combinations in which the mineral constituents of plants exist in the soil, their unequal or uniform distribution in the surface, the composition and physical condition of the subsoil, the relative depth of both, the porosity of the land, and especially the power of absorbing and retaining, as well as modifying in a variety of ways the crude manuring agents which are applied to the land, unquestionably are intimately connected with the great variations which we notice in the agricultural capabilities of different soils.

Before the publication of Liebig's celebrated "Chemistry in its Application to Agriculture," a work which has given the death-blow to the humus theory, the fertility or barrenness of a soil was generally considered to depend entirely upon its physical properties and the presence or deficiency of humus. Soon after the publication of Liebig's writings, scientific men fell into the opposite extreme, and expected the bare chemical analysis of a soil and the ash-analyses of plants would enable them to discover at once the means of restoriug the fertility of land, or to improve it by certain purely mineral manuring mixtures, and to grow on it, irrespective of its natural adaptation to the growth of particular crops, any kind and almost every amount of agricultural produce.

These unphilosophical views have rendered agricultural chemistry less popular than formerly, but also more scientific and more directly useful to the enlightened agriculturist.

A new direction to chemico-agricultural inquiries was given about ten years ago by Professor Way's highly important researches on the absorptive powers of soils for manure. Professor Way's investigations originated in an observation of Mr. Thompson, of Kirby Hall, York, who found that soils have the faculty of separating ammonia from its solution.

On passing solutions of ammonia through different soils, Way found that all possess the power of retaining ammonia, some more, some less. He also observed that potash, lime, magnesia, and phosphoric acid are absorbed by all soils to a considerable extent.

Still more important are his experiments, which prove that cultivated soils not only absorb free alkalies and acids, but have likewise the power of separating ammonia, potash, and other bases from their saline combinations.

Professor Way principally operated with simple salts: it may therefore be urged, that it by no means follows, as a necessary consequence, that because a soil absorbs ammonia when a solution of sulphate of ammonia is passed through it, the same absorption will take place when an ammoniacal salt mixed with some dozen other substances is filtered through it.

I therefore operated with complex liquids, and already, in 1857, published several filtration experiments in the Journal of the Royal Agricultural Society.

These and many subsequent experiments have shown that all soils not only possess the power of absorbing and retaining potash, ammonia, phosphoric and silicic acid, and other mineral matters, but also of modifying in the most varied way the composition of complex saline solutions which are passed through them.

The following Table shows the results obtained in filtering the same kind of liquid manure through two very different soils:—

COMPOSITION of LIQUID MANURE before and after Filtration through Two Soils from the Neighbourhood of Cirencester.

An Imperial Gallon contains:—	No. 1. Calcareous Clay Soil.			No. 2. Ferruginous Sterile Sandy Soil.	
	Before Contact with Soil.	After Contact with Soil.	Loss or Gain.	After Contact with Soil.	Loss or Gain.
Water and volatile ammonia compounds	69,888·14	69,886·60	—1·54	—69,894·25	+ 6·11
Containing:—					
Ammonia, as carbonate and humate of ammonia . . .	(35·58)	(20·81)	—14·77	—(33·15)	— 2·43
Organic matters	20·59	34·77	+14·18	—(25·06)	+ 4·47
Containing nitrogen . . .	(1·49)	(1·84)	+ ·35	— (1·70)	— ·09
Equal to ammonia	(1·81)	(2·23)	+ ·42	— (1·70)	— ·11
Inorganic matters	(91·27)	(78·63)	—12·64	—(80·69)	—10·58
Consisting of:—					
Soluble silica.	2·34	·70	— 1·64	— 5·10	+ 2·76
Oxide of iron	none	2·55	+ 2·55	— 2·07	+ 2·07
Lime	11·48	22·42	+10·94	— 8·03	— 3·45
Magnesia	2·87	1·17	— 1·70	— ·74	— 2·13
Potash	16·92	3·40	—13·52	—12·01	— 4·91
Chloride of potassium . . .	2·74	none	— 2·74	none	— 2·74
Chloride of sodium	40·35	33·31	— 7·04	—39·25	— 1·10
Phosphoric acid	4·83	·60	— 4·93	— 1·92	— 2·91
Sulphuric acid	3·94	2·88	— 1·06	— 3·67	— ·27
Carbonic acid, and loss . . .	5·80	11·60	+ 5·80	— 7·90	+ 2·10
	70,000·00	70,000·00		70,000·00	

The preceding analytical results, amongst other particulars, show:—

1. That the calcareous clay soil absorbed about six times as much ammonia from the liquid manure, as the sterile sandy soil.

2. That the liquid manure in contact with the calcareous clay soil, becomes much richer in lime; whilst during its passage through the sandy soil, it becomes purer in lime.

3. That the calcareous soil absorbed much more potash than the sandy soil.

4. That chloride of sodium, in conformity with the results of other observers, was not absorbed to any extent by either soil.

5. That both soils removed from the liquid most of the phosphoric acid.

6. That the liquid in passing through the calcareous soil becomes

orer; and, on the other hand, in passing through the sandy soil be- mes richer in soluble silica.

The property of soils to store up food for plants is thus not con- ed to one particular kind of fertilizing matter, but it applies to them l, and manifests itself in a way which is modified by the composition the soil.

In these, and in all other experiments which I have since made, e ammonia, potash, phosphoric acid, and other fertilizing matters ntained in a solution were never completely absorbed by any soil, wever weak or concentrated the solutions were that were filtered rough the soil. Indeed, if the solution of saline matters which are rought into contact with soil are very dilute, scarcely any absorption f ammonia, potash, or phosphoric acid takes place.

Sewage of towns, on account of the very diluted condition in which is liquid is usually found, in percolating through a soil scarcely leaves y of its soluble constituents in the soil in a fixed or less soluble form, though the soil possesses in a high degree the power of absorbing and taining soluble fertilizing matters.

All soluble saline matters, however useful or necessary they may e, impede the rapid growth of plants if they are presented too abun- ntly or in too concentrated a solution to the roots of plants. One f the functions of the soil appears to be to transform such readily oluble compounds into combinations so little soluble in water, that hey pass in common life as insoluble, but which are still sufficiently oluble to supply the growing plant with the necessary amount of ineral food in a state of solution.

This beautiful power of soils thus not only effectually prevents the aste in fertilizing matters which heavy rains would otherwise occasion, ut also rectifies in a great measure any misapplication which may be ade of concentrated soluble fertilizers.

The power of soils to modify manuring matters depends in a great easure on the chemical composition of the soil, and also on the con- entration of the liquid and the quantity of soluble fertilizing matters hich is incorporated with that portion of the soil which is penetrated y the roots of plants. Hence the effect which one and the same anure is capable of producing varies greatly in different soils, and lso with a rainy or dry season.

The office of the soil is not merely to supply mineral food to plants, ut also to manufacture, so to say, crude food into a condition fit for similation; to prevent injury to the living plant by too large an accu- ulation of soluble matters in the surface soil; to store up for future se such an excess; to diffuse it equally in that portion of the land ached by the roots of plants; and to modify it in conformity with the quirements of our crops, in a manner differing with each description f land.

Respecting the causes of the absorbing properties of soils, the pinions of chemists are divided.

Liebig regards this power as analogous to, if not identical with the physical power which charcoal possesses in retaining colouring matters, and consequently considers the soluble fertilizing matters which are brought into contact and absorbed either wholly or partially by the surface soil, as present in what he calls a physical state of combination.

Professor Way, on the other hand, believes the absorption to be due to the presence of certain double silicates of alumina in the soil. Thus, for instance, the double silicate of alumina and soda when brought into contact with lime, according to Way, parts with its soda and takes up lime. When the double silicate of alumina and lime thus formed is brought into contact with magnesia, lime passes into solution, and a double silicate of alumina and magnesia is formed; this in its turn is decomposed by a salt of potash; and the double silicate of alumina and potash by a salt of ammonia; thus finally, a double silicate of alumina and ammonia is produced.

Such displacements indeed took place on repeating Way's experiments: but when a preparation made after Professor Way's directions, and containing silica, alumina, and ammonia, is mixed with an excess of a solution containing a salt of potash, ammonia passes into the solution and potash is absorbed by the preparation. From a similar preparation containing silica, alumina, and potash, an excess of a solution of a lime salt removes potash, and lime becomes absorbed.

But as in no case I have been able to notice a substitution of one base for another in equivalent proportions, and no double silicate of a definite composition can be produced by Mr. Way's plan of operation, and the existence of such definite compounds in soils has never been demonstrated, I would suggest a different cause or causes which are in operation when potash, ammonia, and other fertilizing matters are fixed in the soil.

The absorption of soluble fertilizing matters by soils I believe may readily be explained by a reference to well-known chemical facts. The absorption of soluble phosphates or phosphoric acid is readily explained by the affinity which carbonate of lime, oxide of iron, and alumina, which occur in every fertile soil, possess for phosphoric acid.

In the absorption of potash and ammonia, I am of opinion that the hydrated oxides of iron and alumina in the soil have a great share. Like all bases of the formula R_2O_3, these oxides in a hydrated condition, in relation to strong alkalies, are weak acids, in consequence of which they have a tendency to unite with potash or ammonia under favourable circumstances.

The absorption of ammonia, potash, and of phosphoric acid by soils accords with well-known chemical facts; and as these substances are by far the most important fertilizing agents, it may be maintained that the principal absorptive properties of soils are due to chemical and not to purely physical causes.

The mechanical or physical condition of soils, however, affects very materially their productive powers; and it is only in a soil in a

physical condition that the chemical properties can properly
t themselves.

at stress is laid by Liebig, as it is indeed by all good farmers,
mechanical cultivation of the land. Liebig directs special
n to the physical state of combination, as he calls it, in which
eral matters must exist in the surface soil, in order that they
of utility to the plant. Whatever may be the precise meaning
term "physical state of combination," or whether we assume
neral food must be presented to plants in solution, or in some
nysterious form variously represented in Liebig's "Laws of
dry," certainly mineral food cannot be of any service to plants
it be present in the surface soil in an available form. The
'available," perhaps conveys as correct a meaning as the more
nd less graphic expression, "physical state of combination."

uch an available condition mineral food cannot be brought
e surface soil, unless water can freely percolate through the
This is effected by various mechanical means, such as subsoil-
ch-ploughing, surface stirring, &c. By all these means the
, and with it its capillary attraction, is improved. As soon as
ed dry and warmer weather sets in and vegetation makes a
art, the mineral food prepared previously in the lower strata
oil begins to move in an upward direction. With the evapora-
moisture from the surface, fresh food is conveyed into the sur-
il by capillary attraction, and thus the fertility of the latter is
restored. The appearance of nitre, and similar saline effloresc-
on the surface of soils during long-continued dry weather,
ntly shows the display of capillary attraction.

s explains why the exhausted surface of land, abounding at a
depth in mineral riches, remains unproductive when it rests on
pervious undrained subsoil; why winter-fallow does not
lly restore the fertility of the surface if it is not accompanied
ated ploughings, subsoiling, and similar mechanical operations,
to increase its porosity; and why in a well-cultivated clay-
etation is most luxuriant when the intervals between wet and
ther are neither too short nor too prolonged.

king at the different soils of England, we meet with two ex-
—naturally barren sands and rich fertile clays. Between these
tremes we find all gradations; some partaking more of the
ers of the one class, and others more of the properties of rich
d.

ny originally barren soils, by dint of abundant manuring, the
ion of green crops, which are consumed on the land by fatten-
ep, by the purchase of oil-cakes and other kinds of concentrated
d the increased production of home-made manure, have been
into a high state of cultivation. But although in this im-
condition they yield large crops of wheat, barley, and roots, it
dly be said that their permanent fertility has been materially
d. Left to themselves, they soon again become unproductive,

and therefore require constantly a renewal of those constituents which are removed in the crops grown on such land. High farming, in reference to light sandy soils, restores to the land infinitely more mineral matter of the most valuable kind than is removed in the corn-crops sold off the farm. As regards such land, high farming cannot therefore be called a system of robbery.

Deep, rich clay-soils, on the other hand, often contain, practically speaking, an inexhaustible supply of potash, phosphoric acid, magnesia, soluble silica, &c. The amount of mineral matter taken from such land by a long succession of the most exhausting crops is quite insignificant in comparison to that existing in twelve or eighteen inches of soil.

The actual state of fertility of land, however, does not so much depend upon the absolute amount of mineral plant-food in a given depth of soil, as upon the proportion which exists in the surface in an available condition, or as Liebig calls it a "physical state of combination."

Mechanical cultivation, the judicious use of ammoniacal manures, the restoration of particular mineral matters which, like phosphoric acid, are most speedily removed from the surface and alternate cropping, are some of the means of repairing the fertility of the surface.

On light sandy soils, deficient in potash, phosphoric acid, and other mineral matters, ammoniacal salts or nitrate of soda should be avoided; but on soils abounding in mineral food, such dressings may be used with great advantage.

Ammoniacal salts certainly increase the solubility of mineral matters and promote their diffusion in the soil. Still, making all allowance for this, they appear to have a special effect on some crops and not on others. Thus cereals are improved by them, but not clover or beans. In a series of most valuable experiments by Messrs. Lawes and Gilbert, the plots continually manured with mineral matters produced only a slightly increased crop of wheat, nor was the produce increased to any extent in those years in which mineral manures were put on the land every alternate year; whereas in the years in which ammoniacal salts were applied alternately one year and mineral matters the following, a very great increase in the wheat crop was obtained, which was likewise the case when ammoniacal salts were continuously used year after year.

With regard to the relative importance of the various fertilizing matters, it may be stated that ammonia or nitrates unquestionably are most useful substances, which the intelligent farmer may turn into profitable account, and the unreasoning one often abuses in a high degree.

But as the atmosphere as well as the rain invariably contain both ammonia and nitric acid, and as all cultivated soils contain both ready-formed ammonia and nitrogenized organic matters, which on gradual decomposition furnish ammonia or nitric acid or both, the application to the soil of nitrates or ammoniacal salts is not of the same essential primary importance as that of those mineral matters in which the land is deficient. Magnesia, lime, silica, sulphuric acid, chloride of sodium, and even potash, are either present in most soils in great abundance, or if deficient in particular soils, may be economically incorporated with them in the shape of marl, burnt clay, or gypsum, by the consumption of purchased food on the land. All these mineral matters have much less value than phosphoric acid, which is but sparingly distributed in most soils, and is largely required by all plants. Accordingly the removal of phosphoric acid from the land leads more rapidly to partial exhaustion, especially of naturally poor soils, than the removal of any other ash-constituent. Fortunately modern science and commercial enterprise have brought to light the fact, that large deposits of phosphatic materials occur far more abundantly in various parts of the world, than was supposed not many years ago.

[Of the phosphatic materials actually used in England for the manufacture of artificial manures, the following were exhibited:—South American bone-ash; Cambridgeshire and Suffolk coprolites; apatite from Norway; phosphorite from Estremadura; Sombrero, or rock guano, and phosphatic crusts, from Monk's Island, Jarvis Island, Baker Island, and various other small islets in the Caribbæan Sea.]

Should the supply of Peruvian guano come to an end, which it will before many years, English agriculturists will still continue to reap the benefits which commercial enterprise, manufacturing skill and capital, more extended agricultural knowledge, steam-power applied to the cultivation of the land, intelligent labour and applied science have already conferred upon this highly-favoured country.

Conclusive proofs can be given, showing that so far from being in a progressive state of exhaustion, the productiveness of the soils of England has wonderfully increased during the last fifty years; and that the deplorable but hitherto unavoidable loss which the sanitary laws of a civilized country necessitate, is perfectly insignificant in comparison with the immense amount of mineral riches in the great majority of soils, and with the abundant restoration of fertilizing matters to naturally poor land.

[A. V.]

WEEKLY EVENING MEETING,

Friday, May 15, 1863.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President,
in the Chair.

William Odling, Esq. M.B. F.R.S.
SECRETARY TO THE CHEMICAL SOCIETY.

On the Molecule of Water.

Does the molecule of water consist of a single combining proportion of hydrogen having the relative weight 1, united with a single combining proportion of oxygen having the relative weight 8, or does it consist of two combining proportions of hydrogen having each the relative weight 1, united with a single combining proportion of oxygen having the relative weight 16? In other words, ought the molecule of water to be represented by the formula HO', in which O' stands for 8 parts by weight of oxygen, or by the formula H_2O'', in which O'' stands for 16 parts by weight of oxygen? The question is entirely one of fact. If the hydrogen of water is experimentally indivisible, it necessarily constitutes an indivisible proportion, or atomic proportion, or so called atom. If, on the other hand, it is experimentally divisible into two equal parts, it must consist of at least two atomic proportions, or two atoms.

Similar questions with regard to the molecular formulæ of other compounds have been decided with an almost absolute unanimity. Thus chlorhydric or muriatic acid gas consists of 1 part by weight of hydrogen united with 35·5 parts by weight of chlorine, and its molecule is represented by the formula HCl, in which H stands for a single combining proportion of hydrogen, and Cl for a single combining proportion of chlorine, having 35½ times the weight of the single combining proportion of hydrogen.

Phosphoretted hydrogen gas consists of 1 part by weight of hydrogen united with 10·3 parts by weight of phosphorus. Its molecule, however, is not represented by the formula HP', in which H stands for a single combining proportion of hydrogen having the relative weight 1, and P' for a single combining proportion of phosphorus having the

elative weight 10·3 ; but by the formula H_3P''', in which H_3 stands for
aree separable proportions of hydrogen having each the relative
reight 1, and P''' for a single indivisible proportion of phosphorus
aving the relative weight 31.

Silicated hydrogen gas consists of 1 part by weight of hydrogen
nited with 7 parts by weight of silicon. Its molecule, however, is
ot represented by the formula HSi', in which Si' stands for 7 parts of
licon ; or yet by the formula H_3Si''', in which Si''' stands for 21 parts
f silicon, as the resemblance in properties between silicated and phos-
horetted hydrogen might seem to require ; but by the formula
H_4Si'''', in which H_4 stands for four separable proportions of hydrogen
aving each the relative weight 1, while Si'''' stands for a single indi-
isible proportion of silicon having the relative weight 28.

Why then do chemists represent chlorhydric acid, and its prototype
uorhydric acid, as each containing one combining proportion of hy-
rogen ; phosphoretted hydrogen, and its prototype ammonia, as each
ontaining three combining proportions of hydrogen ; and silicated
ydrogen, and its prototype marsh-gas, as each containing four com-
ining proportions of hydrogen? For all are agreed that in the
olecules of fluorhydric acid and chlorhydric acid there is one part of
ydrogen united with 19 parts of fluorine, and 35·5 parts of chlorine
spectively; that in the molecules of ammonia and phosphoretted
ydrogen there are three parts of hydrogen united with 14 parts of
itrogen, and 31 parts of phosphorus respectively; and that in the
olecules of marsh-gas and silicated hydrogen there are four parts of
ydrogen united with 12 parts of carbon, and 28 parts of silicon
spectively.

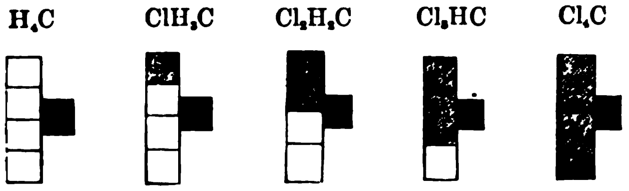
The reasons by which chemists are induced to be so seemingly in-
onsequent are very numerous, and some of them very recondite ; but
e reason of greatest weight and most obvious character is drawn
om the phenomena of substitution ; by which is meant the change
fected in the composition of various bodies, by the abstraction of
rtain of their constituent elements, and the introduction of certain
ther elements or groupings in their stead. Thus we have sodium-
lcohol, in which a portion of the hydrogen of common alcohol is sub-
ituted by its equivalent of sodium ; bromaniline, in which a portion
f the hydrogen of common aniline is substituted by its equivalent of
romine ; nitrophenol, in which a portion of the hydrogen of common
henol is substituted by its equivalent of peroxide of nitrogen ; and
in very many other instances. Now the conclusions deducible
om the phenomena of substitution, whether elementary or compound,
irect or indirect, obvious or latent, are, as will presently appear, of
e greatest importance in determining the molecular formulæ of com-
ound bodies.

It is evident, for instance, that the molecule of marsh-gas must
ntain four proportions of hydrogen, because we are able to replace
$\frac{2}{4}$, $\frac{3}{4}$, and $\frac{4}{4}$ of its hydrogen by four successive substitutions, to pro-
ce a series of bodies differing from one another by a regular gradation

of properties. Thus the final product of the action of chlorine upon marsh-gas is a compound in which all the hydrogen of marsh-gas is replaced by its equivalent of chlorine; so that if we consider the molecule of marsh-gas to consist of one combining proportion of hydrogen united with 3 parts by weight of carbon, then the molecule of its chloro-derivative will consist of one combining proportion of chlorine united with 3 parts by weight of carbon; or if we represent the molecule of marsh-gas to consist of four combining proportions of hydrogen united with 12 parts by weight of carbon, then the molecule of its chloro-derivative must consist of four combining proportions of chlorine united with 12 parts by weight of carbon; as shown in the following table:—

$C' = 3$		$C'''' = 12$	
(3)	HC'	H_4C''''	(12)
(12)	$3HC'.\ ClC'$	$Cl\ H_3C''''$	(12)
(6)	$HC'.\ ClC'$	Cl_2H_2C''''	(12)
(12)	$HC'.\ 3ClC'$	$Cl_3H\ C''''$	(12)
(3)	ClC'	Cl_4C''''	(12)

Now exactly intermediate between the original hydride and the final chloride is a body which contains hydrogen and chlorine in equivalent proportions, and which consequently cannot be represented with less than 6 parts by weight of carbon, and may of course be represented with 12 parts; while intermediate between this body and marsh-gas on the one hand, and between it and chloride of carbon on the other, are two additional compounds, the one containing three combining proportions of hydrogen and one combining proportion of chlorine, the other containing three combining proportions of chlorine and one combining proportion of hydrogen, and both of them consequently incapable of being represented with less than 12 parts by weight of carbon. There are thus two sets of formulæ presented for selection; the one representing the above-mentioned compounds with unequal quantities of carbon by the simplest possible individual formulæ, the other representing them with an equal quantity of constituent carbon by the simplest possible series of formulæ; and a little consideration has led chemists to the unanimous opinion that the formulæ in the second column do, while those in the first column do not, express the actual correlations of the bodies represented. For these bodies manifest in every respect a regular seriation of properties, such as necessarily would be the case if their molecules differed from one another only by a gradually increasing substitution of chlorine for hydrogen; but such as could not be the case if the constituent carbon of their respective molecules varied in the ratio of 3 to 12, or even of 3 to 6. Moreover, by adopting the formula H_4C'''' for marsh-gas we perceive at once why in its chloro-derivatives the hydrogen and chlorine should always stand to one another in the relation of fourths. But if marsh-gas is to be represented by the formula HC′, and its chloro-derivatives regarded as compounds of HC′ with ClC′, there is no reason why we should not have compounds of 1 HC′ with 2 or 5, or 6 of ClC′, or of 2 HC′ with 3 ClC′, &c., in which the hydrogen would stand to the chlorine in the relation of a third, or of two-thirds, or of a fifth, or of a sixth, &c. But with the tetrahydric model, corresponding to the formula H_4C'''', and represented below, the successive displacement of the hydrogen of marsh-gas in fourths, and in no other proportion, becomes perfectly intelligible, thus:—



By the action of chlorine upon marsh-gas, there are produced in succession monochloromethene, in which one-fourth of the hydrogen is displaced by chlorine; then dichloromethene, in which two-fourths of the hydrogen are displaced by chlorine; then trichloromethene or chloroform, in which three-fourths of the hydrogen are displaced by chlorine; and lastly, tetrachloromethene, in which all four-fourths of the hydrogen are displaced by chlorine. If, then, we take 1 relative part of hydrogen as the least indivisible proportion of hydrogen that can enter into a combination, it is evident that the molecule of marsh-gas must contain four such parts, or four combining proportions, or, in common parlance, four atoms of hydrogen.

The case of ammonia is even more striking than that of marsh-gas. When we effect the substitution of some element or grouping for the hydrogen of ammonia, the substituted and remaining hydrogen are not related to one another in fourths, as happens with marsh-gas, but always in thirds. When, for instance, potassium is heated in ammonia, there is produced the compound known as potassamide, which consists of one combining proportion of potassium, and two combining proportions of hydrogen—one-third of potassium and two-thirds of hydrogen —united with 14 parts by weight of nitrogen. Again, when ammonia is acted on by iodine, there is produced the very explosive body known as diniodamide, which consists of two combining proportions of iodine and one combining proportion of hydrogen—two-thirds of iodine and one-third of hydrogen—united with 14 parts by weight of nitrogen. While if we act upon ammonia by excess of chlorine, we obtain the highly-dangerous compound known as trichloramide or chloride of nitrogen, in which all the hydrogen of ammonia is replaced by chlorine. But the most satisfactory evidence of the trihydric character of ammonia is afforded by Hofmann's experiments on the volatile organic bases, in which he succeeded in replacing one-third, two-thirds, and three-thirds of the hydrogen of ammonia by one and the same radicle, and by a continuation of one and the same process; thus:—

	$N' = 4 \cdot 7$	$N''' = 14.$	
(4·7)	HN'	H_3N'''	(14)
(14)	$2HN'.\ EtN'$	$Et\ H_2N'''$	(14)
(14)	$HN'.\ 2EtN'$	$Et_2\ H\ N'''$	(14)
(4·7)	$Et\ N'$	$Et_3\ N'''$	(14)

The composition of ethylamine and diethylamine cannot possibly be expressed with less than 14 parts by weight of nitrogen, whilst that of ammonia and triethylamine might be represented with one-third of that quantity, or with 4·7 parts. But all four bodies present such a marked resemblance to one another, and such a regular gradation of properties, as could not be the case unless their respective molecules were strictly comparable in constitution. For instance, their boiling points and vapour-densities increase by a regular progression, according to the regular increase in the substitution of ethyl for hydrogen; whereas it is certain that the boiling point and vapour-density of a body containing but one proportion of ethyl and 4·7 parts of nitrogen would bear no relation of series to the boiling points and vapour-densities of bodies containing three proportions of conjoint hydrogen and ethyl united with 14 parts by weight of nitrogen. Moreover, by adopting the trihydric model for ammonia, corresponding to the formula H_3N''', we perceive at once why the replacement of its hydrogen must take place in thirds; or, in other words, why we cannot obtain ammonias in which one-half or one-fourth of the hydrogen is replaced by equivalent substitution, but only those in which one-third or two-thirds is so replaced; thus:—

H_3N''' EtH_2N''' Et_2HN''' Et_3N'''

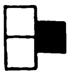
Again, ammonias are known to chemists in which two-thirds of the hydrogen are replaced by one, and the remaining third of hydrogen by some other radicle; or in which all three thirds are replaced by three different radicles, as instanced by diethyl-phenylamine Et_2PhN''', and methyl-ethyl-phenylamine $MeEtPhN'''$, for example.

Seeing, then, that there are bodies, such as marsh-gas and silicated hydrogen, of which the hydrogen is replaceable in fourths at four successive stages, and which are consequently represented with four atoms of hydrogen; and that there are other bodies, such as ammonia nd phosphoretted hydrogen, of which the hydrogen is replaceable n thirds at three successive stages, and which are consequently repre-ented with three atoms of hydrogen,—it is not *à priori* improbable that here may be yet other bodies, such as water and sulphydric acid, in hich the hydrogen is replaceable in halves at two successive stages, nd which must consequently be represented with two atoms of ydrogen. If we act upon water by excess of metallic sodium, for nstance, we obtain the compound known as oxide of sodium; and ccordingly as we represent the molecule of water by the formula HO', in which O' stands for 8 parts by weight of oxygen, or by the ormula H_2O'', in which O'' stands for 16 parts by weight of oxygen, so ust we represent oxide of sodium by the formula NaO', or Na_2O''; hus :—

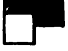
	$O' = 8$	$O'' = 16$	
(8)	HO'	H_2O''	(16)
(16)	$HO'.NaO'$	$NaHO''$	(16)
(8)	NaO'	Na_2O''	(16)

But exactly intermediate between water and oxide of sodium, we ave the very definite compound known as hydrate of sodium, which onsists of one combining proportion of sodium and one combining roportion of hydrogen united with 16 parts by weight of oxygen, and hich cannot be represented save with 16 parts by weight of oxygen. Now, just as the three intermediate bodies between marsh-gas and hloride of carbon force us to represent these extreme bodies with 12 arts of carbon, so that all five may appear as members of one and the ame series; just as the two intermediate bodies between ammonia and riethylamine force us to represent these extreme bodies with 14 parts f nitrogen, so that all four may appear as members of one and the ame series; so must the intermediate body between water and oxide f sodium force us to represent these extreme bodies with 16 parts of xygen, so that all three may appear as members of one and the same eries. If marsh-gas and chloride of carbon must be represented by ormulæ similar to those of their intermediate bodies, and consequently with four atoms of hydrogen and chlorine respectively; if ammonia nd triethylamine must be represented by formulæ analogous to those f their intermediate bodies, and consequently with three atoms of ydrogen and of chlorine respectively; then water and oxide of sodium ust be represented by formulæ analogous to that of their intermediate ody, and consequently with two atoms of hydrogen and of sodium espectively. In the intermediate carbon-bodies, the remaining and eplaced hydrogen form fourths of the whole; in the intermediate itrogen bodies, the remaining and replaced hydrogen form thirds of he whole; while in the intermediate oxygen compound, the remaining nd replaced hydrogen form halves of the whole. Hence, if the olecule of marsh-gas is to be represented by a tetrahydric model, and that of ammonia by a trihydric model, then the molecule of water must be represented by a dihydric model; thus:—

H_2O''



$NaHO''$



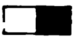
Na_2O''

When water is acted upon by metallic sodium, one equivalent of sodium expels one equivalent of hydrogen, to form the well-defined body hydrate of sodium, and the action proceeds no further. But when melted hydrate of sodium, at a temperature approaching that of redness, is acted upon by metallic sodium, a second equivalent of sodium turns out a second equivalent of hydrogen, to produce oxide of sodium. This replacement of the hydrogen of water by sodium at two successive stages,—the first stage of replacement taking place at ordinary temperatures, and the second stage at a dull red heat,—is even better defined than the replacement of the hydrogen of ammonia by ethyl at three successive stages, and than the replacement of the hydrogen of marsh-gas by chlorine at four successive stages.

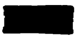
But the formation of ether from water by Williamson's process, affords a still closer resemblance to Hofmann's formation of triethylamine from ammonia. Water H_2O'', when acted upon by potassium, yields hydrate of potassium, or potassic water KHO''. Hydrate of potassium acted upon by iodide of ethyl yields alcohol, or ethylated water $EtHO''$. Alcohol acted upon by potassium yields potassium-alcohol, or ethylated potassic water $EtKO''$. Potassium-alcohol acted on by iodide of methyl yields the first mixed ether, or methylated ethyl-water $EtMeO''$; and when acted upon by iodide of ethyl yields common ether, or ethylated ethyl-water Et_2O''. None of the intermediate bodies can be represented save with 16 parts of oxygen, and hence the terminal bodies being members of the same series, must be also represented with 16 parts of oxygen. The intimate relations and analogies of ethylated methyl-water $EtMeO''$ and diethylated water Et_2O'', as regards modes of formation, modes of decomposition, boiling point, vapour-density, &c., will not allow the molecule of the mixed ether to be represented with 16 parts, and that of the common ether with only 8 parts of oxygen; any more than the relations and analogies of ethyl-methyl-phenylamine $EtMePhN'''$ and triethylamine Et_3N''' will allow the molecule of the former compound to be represented with 14 parts, and that of the latter with only 4·7 parts of nitrogen.

With regard to chlorhydric acid, there is no intermediate stage in the replacement of its hydrogen; the substitution taking place at once or not at all. We have, for instance, chloride of hydrogen HCl, chloride of ethyl $EtCl$, and chloride of sodium $NaCl$, but no intermediate bodies; whence the representation of chlorhydric acid by the simple monhydric model, thus:—

HCl



NaCl



In addition to the above-mentioned chemical parallel, there is one very remarkable physical relation subsisting between marsh-gas, ammonia, water, and chlorhydric acid, namely, that all four molecules occupy the same bulk. Two cubic feet, for instance, of chlorhydric acid-gas HCl, yield 1 cubic foot of hydrogen and 1 cubic foot of chlorine. Two cubic feet of steam H_2O, yield 2 cubic feet of hydrogen and 1 cubic foot of oxygen. Two cubic feet of ammonia H_3N, yield 3 cubic feet of hydrogen and 1 cubic foot of nitrogen; while two cubic feet of marsh-gas H_4C, yield 4 cubic feet of hydrogen and a quantity of carbon of which the gaseous volume has not been and cannot be ascertained. With equal volumes of all four gases, the marsh-gas contains four times as much, the ammonia three times as much, and the steam twice as much hydrogen as the chlorhydric acid.

Many other arguments may be adduced to show that the molecular weight of water is 18, corresponding to the formula H_2O'', and not 9, corresponding to the formula HO'. Thus water is concerned as the agent or product of some chemical reaction more frequently than any other body with which chemists are acquainted: but in no well-defined reaction do we ever find the reacting or resulting water expressible by 9 parts, or three times 9 parts, or five times 9 parts, &c., but in every case by 18 parts, or some multiple of 18 parts, as instanced in the following examples, which might be increased indefinitely:—

Formation of Nitro-benzol.

$$C_6H_6 + HNO_3 = C_6H_5(NO_2) + H_2O'' \text{ or } 2HO'$$

Decomposition of Zinc-ethyl.

$$2C_2H_6 + ZnH_2O_2 = Zn(C_2H_5)_2 + 2H_2O'' \text{ or } 4HO'$$

Formation of Hydro-benzamide.

$$3C_7H_6O + 2H_3N = C_{21}H_{18}N_2 + 3H_2O'' \text{ or } 6HO'$$

Decomposition of Pentachloride of Phosphorus.

$$H_3PO_4 + 5HCl = PCl_5 + 4H_2O'' \text{ or } 8HO'$$

Again, in the great majority of direct compounds which water forms with other bodies, the combining water necessarily constitutes 18 parts, or some multiple of 18 parts; and when two or more bodies differ from one another by the quantities of water they respectively contain, the differential quantity always amounts to 18 parts or some multiple of 18 parts, thus :—

		$C_{10}H_{16}$	Turpentine.
$C_{10}H_{16} . H_2O$	or	$C_{10}H_{18}O$	Monhydrate.
$C_{10}H_{16} . 2H_2O$	or	$C_{10}H_{20}O_2$	Dihydrate.
$C_{10}H_{16} . 3H_2O$	or	$C_{10}H_{22}O_3$	Trihydrate.
		CNH	Prussic Acid.
$CNH . H_2O$	or	CNH_3O	Formamide.
$CNH . 2H_2O$	or	CNH_5O_2	Formate of Ammonia.

Several chemists, during what may be termed the transitional stage of their views, were accustomed to represent the molecule of water by the formula $H_2O'_2$, in which O′ stands for 8 parts of oxygen, instead of by the formula H_2O'', in which O″ stands for 16 parts by weight of oxygen. But the use of this formula really showed an imperfect appreciation of the grounds upon which the abandonment of the simpler formula HO′ was based; for if the molecule of water is to be represented with two proportions of hydrogen, because its hydrogen is divisible into two parts, *invertendo* it must be represented with but one proportion of oxygen, because its oxygen is indivisible. Now that the oxygen of water is indivisible is acknowledged alike by those who use the formula H_2O'' and those who use, or rather used, the formula $H_2O'_2$; and such being the case, the representation of the oxygen of water by the expression O'_2 is quite unwarrantable, for the conception of two inseparable proportions of oxygen having each the value 8, amounts after all to that of a single indivisible proportion of oxygen having the value 16.

That the oxygen not only of water but of all other well-defined oxygenated molecules always amounts to 16 parts, or some multiple of 16 parts, is abundantly evident. For the composition alone of the great majority of oxygenated bodies, prevents them from being represented save with 16 or some multiple of 16 parts of oxygen, just as the composition of chloroform prevents its being represented save with 12 parts of carbon; and as the composition of ethylamine prevents its being represented save with 14 parts of nitrogen. With regard to the remaining oxygenated bodies, their mere composition would allow them to be represented with only 8 or some odd multiple of 8 parts of oxygen, but their several relations to other bodies belonging to the more numerous class prevents them from being represented with so l a quantity; just as the relation of triethylamine to ethylamine diethylamine prevents it from being represented with less than arts of nitrogen, though from its mere composition it might be sented with only 4·7 parts of nitrogen.

rom this it follows, that when two or more bodies differ in com- ion from one another by the proportions of oxygen they respec- y contain, that difference always amounts to 16 parts, or some iple of 16 parts, as shown in the following series:—

HCl	HCl	Chlorhydric acid.
$HClO'_2$	$HClO''$	Hypochlorous acid.
$HClO'_4$	$HClO''_2$	Chlorous acid.
$HClO'_6$	$HClO''_3$	Chloric acid.
$HClO'_8$	$HClO''_4$	Perchloric acid.

$C_4KH_5O'_8$	$C_4KH_5O''_4$	Acid succinate.
$C_4KH_5O'_{10}$	$C_4KH_5O''_5$	Acid malate.
$C_4KH_5O'_{12}$	$C_4KH_5O''_6$	Acid tartrate.

Throughout there is no difference of 8 parts of oxygen or of any multiple of 8 parts of oxygen, between the successive com- ds.

[t follows also that whenever oxygen, with or without some other ent, is added to or taken from a compound, the oxygen so added liminated must always be represented by 16, or some multiple 6 parts, as instanced in the following decompositions, representing liberation of oxygen from nitrate, permanganate, and chlorate of sium respectively:—

$$KNO_3 = KNO_2 + O'' \text{ or } O'_2$$
$$H_2SO_4 + KMmO_4 = 2H_2O + KMm(SO_4)_2 + O''_2 \text{ or } O'_4$$
$$KClO_3 = KCl + O''_3 \text{ or } O'_6$$

Let the decompositions be expressed how they may, the oxygen laced cannot appear as 8 parts, or any odd multiple of 8 parts; and hundreds of other instances.

The representation of the molecule of water by the formula H_2O proposed by Gay-Lussac, advocated by Berzelius, and employed by y more than fifty years ago. Its revival is due to Gerhardt, who njunction with Laurent made it the basis of a consistent system hemistry, since brought to a higher state of development by the urs of many distinguished chemists, including more especially

Professor Williamson, who first introduced it into this country and supported it by a series of most masterly researches.

In accordance with this system, four well-defined classes of primary hydrides are recognized, the leading member of each of which constitutes the type or model to which an infinite variety of compounds are referable as regards both their composition and behaviour; thus:—

Monhydrides.	Dihydrides.	Trihydrides.	Tetrahydrides.
HF	H_2O	H_3N	H_4C
HCl	H_2S	H_3P	H_4Si
HBr	H_2Se	H_3As	
HI	H_2T	H_3Sb	

Formulated as above, all these hydrides occupy the same volume, and their respective vapour-densities compared with that of hydrogen as unity are the halves of their atomic weights.

[W. O.]

WEEKLY EVENING MEETING,

Friday, May 22, 1863.

The Rev. John Barlow, M.A. F.R.S. Vice-President, in the Chair.

Professor Roscoe, B.A. F.C.S.

On the Direct Measurement of the Sun's Chemical Action.

The life of the animal may be described chemically as a process of oxidation: the tissues of his body are continually undergoing combustion, he is constantly breathing out carbonic acid gas, and thus deteriorating the ocean of air at the bottom of which he lives and moves; and if there were not a counteracting influence at work, he would, during each moment of his existence, be working his own destruction. This counteracting influence is exerted by vegetables, whose life is chemically characterised by a change opposite to that of the animal, that, namely, of deoxidation or reduction. Animals take up oxygen and give off carbonic acid; plants reverse the process, they take up carbonic acid and give off oxygen, and thus the balance of atmospheric life is kept [illegible].

The animal derives its power from the forces locked up in the vegetable organisms which constitute its food, and of which it builds up its tissues. When they are destroyed by the action of the atmospheric oxygen, these forces become evident either in motion of the masses, constituting mechanical action, or in the motions of the particles constituting heat, or other manifestations of energy. The animal cannot create force; he can only direct its application: he cannot move a muscle without a certain given quantity of force being changed, without a certain portion of his tissues undergoing oxidation, an amount which is regulated by the grand principle of the conservation of force—so that the total energy which the animal exhibits is regulated by the same laws which apply to the work of the steam or electro-magnetic engine. Every pound of carbon burnt to carbonic acid in the animal body evolves heat enough to raise the temperature of 8080 lbs. of water 1° centigrade, or can produce a mechanical effect sufficient to raise 784 tons one foot high.

The source of the power of the animal is evident; it lives upon the force which has been accumulated by the plant. The animal world cannot continually withdraw energy from the plant, unless the latter receives as continual a supply. The source of this energy is the sun; the plant sucks up or absorbs the rapidly vibrating solar radiations and stores them up to be given out again in the various forms of energy when the vegetable tissue is destroyed by oxidation.

It is only in the presence of the sunlight that the true function of plant life can be exercised. It is the sunlight which, acting on the green colouring matter of leaves, decomposes the carbonic acid of the air into its constituent elements, enabling the plant thus to assimilate the carbon and to turn the free oxygen back into the air.

Only those of the solar rays which vibrate the most rapidly are able thus to tear the particles of carbon and oxygen asunder, or to effect chemical change; and these most refrangible or violet rays have, therefore, been called the chemical rays—not that there is any difference in kind between these and the other solar radiations; they all differ only in wave-length and in intensity of vibration.

These blue rays then, falling on the green portions of plants, are absorbed to do work; their rapid vibrations are used up to set free the carbon and oxygen, and the heat equivalent to these absorbed vibrations is again given off when the carbon thus produced is burnt.

The speaker illustrated the chemical activity of the blue rays, and the inactivity of the red rays, by showing that a bulb filled with chlorine and hydrogen explodes when exposed to an intense blue light, but is unacted upon by an equally bright red light.

The measurement of the amount of these chemically
falling at a given time upon a given spot, n
meteorological interest, as their variation for a
element in the changing plant- and ani
country.

Three years ago (March 2, 1860) the sp
results of a series of experiments undertaken by

himself, for the purpose of obtaining a means of accurately measuring the chemical action of sunlight.

The measure consisted in the quantity of hydrochloric acid formed by the action of light upon a mixture of equal volumes of chlorine and hydrogen gases. The authors succeeded in arranging a most accurate and reliable chemical photometer, by help of which the laws regulating the chemical action of light were investigated, and the distribution of direct and diffuse sunlight upon the earth's surface determined when the sky is unclouded.* The delicate nature of the instrument, which the sensitive substance rendered necessary, precludes the general use of this chlorine and hydrogen photometer, and the method is likewise inapplicable when we wish to measure the total effect produced by the varying cloud and sunshine of our changing climate.

The object of the present research, carried on by Professor Bunsen and the speaker, has been to invent an easy and reliable mode of measuring the daily variation in the sun's chemical intensity which shall be applicable to regular meteorological registration.

Thermometric observations, giving the mean monthly or yearly temperature of a country, by no means yield all the data required for the estimation of the true climatology of the place, or of its plant- and animal-producing capabilities. For this purpose we require to have not only the amount of solar heat directly or indirectly reaching the spot; but likewise the amount of chemically active solar light which falls there. This is strikingly seen when we compare the mean annual temperature of Thorshavn (Faroe Islands) with that of Carlisle.

			Temp. Fah.	Diff.
Thorshavn .	N. lat. 62° 2′	W. long. 6° 46′	. . 45°·6	1°·3.
Carlisle . .	—— 54° 54′	—— 2° 58′	. . 46°·9	

In these two situations the mean annual temperature is nearly equal, but the quantity of sunlight falling upon these two places differs most widely, and we have a corresponding difference in the true climatological relations. Owing to the constant moisture and cloudy state of the atmosphere, which the sun's chemical rays cannot penetrate, the flora of the Faroes and Shetlands is of the most limited description, only the most hardy variety of shrubs and no trees flourishing; whilst at Carlisle we have the most luxuriant vegetation accompanying a more sunny sky. Thus, too, the mean summer temperature of Rejkiavik in Iceland is only 3°·8 Fah. below that of Edinburgh, whilst the difference between the mean summer temperature of Edinburgh and London is 5°·4 Fah. Yet in Iceland no tree grows; whilst between London and Edinburgh, we notice no marked difference as regards the development of vegetable life. Hence we see that places upon the same isothermal do not necessarily possess a truly corresponding climate; this can only be attained when, amongst other conditions, the places are situated upon the curve of equal mean chemical intensity.

---

* Phil. Trans. for 1857, pp. 355, 381, 601; for 1859, p. 879.

Although many fruitless attempts have been made to construct photometers by a comparison of the blackness produced by sunlight upon photographic paper, it was found that in this way the desired end could be attained by attention to certain essential conditions.

For this purpose it was necessary to construct an apparatus in which photographic sensitized paper could be exposed to the sunlight for definite times measured by small fractions of a second. This instrument consists essentially of a pendulum vibrating about ½-seconds, by whose oscillation a sheet of darkened mica is withdrawn from, and brought back over, a horizontal strip of paper prepared with chloride of silver, and fixed in a constant position relative to the pendulum and sheet of mica. The time during which each point in the length of the strip is exposed is different, and the time of exposure for each point can be calculated when the length and position of the strip, and the duration and amplitude of the pendulum's vibration are given.

The strip of sensitive paper presents, after exposure, a gradual diminution of shade from dark to light, and for each shade the time of exposure is known. In order that such a graduated strip may serve as a means of measuring the chemical action of light, we require :—

1. To know the relation existing between the several tints and the intensity of the light necessary to produce such tints.

2. To construct sensitive paper which shall always possess the same degree of sensitiveness, and can easily be prepared when required.

It was found, by a long series of experiments, that it was possible, by adhering strictly to a certain method of manipulation, to prepare standard papers which, when made, possess a constant degree of sensitiveness; so that if the same light falls upon them, the papers are always coloured to the same tint.

Experiment likewise showed that the tint attained by such a paper was constant when the *quantity* of light falling upon it also remained constant; so that light of the intensity 50 falling upon the paper for the time 1, produced the same blackening effect as light of the intensity 1 falling upon it for the time 50.

Knowing this law, which regulates the degree of shade of the paper, and having a surface of a perfectly constant degree of sensitiveness, it is easy to obtain absolute measurements of the chemical action of light. For this purpose an arbitrary unit of measurement is chosen, by making a standard tint or paint which can be easily and exactly reproduced at any time.

The quantity of light which shall, in a second or the unit of time, produce a blackening effect on the standard photographic paper equal to that of the standard tint, is said to have the chemical intensity 1. If the time needed to produce this same tint is found by experiment with the pendulum-photometer to be 2 seconds, then the chemical intensity is one-half, and so on.

All that is needed, in order to obtain accurate measurements of the chemical action of diffuse daylight or sunlight, is to be able to find the time necessary to effect a blackening of the normal paper equal in shade to the standard tint. This is done by means of the graduated strip made in the pendulum-photometer.

For the purpose of accurately comparing these tints, the ordinary daylight or even lamplight cannot be used, as a change would thereby be produced on the sensitive paper. A light which does not act chemically must be used; such a light is the monochromatic soda-flame. The light from this flame possesses another advantage, namely, that the unavoidable differences of colour are not seen; variation in *shade* alone being perceptible. The speaker exhibited the accuracy of this method of observing coincidence in shade by means of a large model of the instrument.

By help of this soda-flame the coincidence of shade of the graduated strip with the standard tint can be read off with the greatest precision. This fact, as well as the possibility of preparing a constant sensitive paper, is seen by reference to the following tables, extracted from the detailed paper printed in the Philosophical Transactions for 1863.

Papers variously prepared were exposed for the same time to the same light.

Each reading is the mean of several observations; identity in the numbers shows identity in the shade, and, therefore, the constant sensitiveness of the papers.

The standard paper is prepared by soaking photographic paper in a solution of common salt of given strength (3 to 100), and then allowing it to lie upon the surface of a silver solution (12 NO_3Ag to 100 of water). When the strength of salt solution varies, the sensitiveness of the paper alters very rapidly. Variation in the strength of the silver-bath produces, on the contrary, but little change in the sensitiveness of the paper. Different qualities of paper and alterations of atmospheric moisture and temperature do not affect the sensitiveness of the paper.

1. *Effect of altering the Strength of the Silver-bath. Paper salted in a Solution containing* 3 *parts Chloride of Sodium to* 100 *of Water.*

	Readings.	
Ag NO_3 to 100 of water.	Observer A.	Observer B.
12	128·6	129·7
10	128·7	127·0
8	128·7	128·0
6	129·7	130·0

2. *Effect of altering the Strength of the Salt Solution.*

	Readings.	
Na Cl to 100 of water.	Observer A.	Observer B.
1	62·6	60·4
2	95·7	94·6
3	132·6	129·6
4	167·0	168·0

. *Experiment showing the constant Sensitiveness of the Standard Paper.*

Paper.	Na Cl to 100 of water.	Intensity No. 1.		Intensity No. 2.	
		Observer A.	Observer B.	Observer A.	Observer B.
er part of sheet 2	2·950	70·2	70·0	101·3	101·5
er part of sheet 2	3·026	70·6	69·3	101·5	101·7
lle of sheet 1 .	3·026	70·0	69·5	100·9	100·9
lle of sheet 3 .	3·000	70·0	70·4	101·0	100·0

All these papers were silvered in a solution containing 12 parts of ate of silver to 100 of water.

In order to measure the chemical intensity of the daylight at any , all that is needed is to expose a strip of standard paper in the ulum-photometer for a given number of vibrations, and then to upon the strip, thus exposed, the point at which a shade equal to standard tint has been produced. Reference to a table gives the of exposure necessary to produce this tint, and the reciprocal of time represents the intensity of the acting light. If the time ssary were 3 seconds, the chemical intensity would be ⅓; if the were ½ second, the intensity would be 2. In this way curves of y chemical intensity were exhibited, which show the variation ed by clouds, or by the changing altitude of the sun. These curves maxima and minima exactly corresponding to the appearance and ppearance of the sun behind a cloud. The difference between the chemical intensity in summer and winter is thus also clearly icted.

Based upon the principles of the pendulum-photometer, a much ler method of making these measurements has been arranged, as ws. A graduated strip made in the pendulum-photometer is fixed yposulphite of soda, and pasted upon a board furnished with a . The shades of certain points on this fixed strip are compared the shades on given points upon a graduated strip prepared in the l way, and not fixed in hyposulphite. The fixed strip is thus rated in terms of the unit of measurement, and it may then be as a means of measuring the chemical action of light. Small es of the standard paper are then exposed for a given time to the which it is desired to measure, until the shade approaches that of rt of the fixed strip. The point of exact coincidence is then read y the soda flame as usual. In this way a piece of standard paper square-inch of area will serve for 20 separate determinations, and whole arrangement for exposure may be carried in the pocket. curve of the chemical intensity of day and sunlight in Manchester, on May 15th, 1863, made with this small instrument, fully bears out the accuracy and ease with which these measurements can be made, and the results of his experiments induced the speaker to express a hope that before long these instruments may be introduced into meteorological observatories.

The determination of the chemical brightness of the various portions of the sun's disc is an interesting application of this new method of photometric measurements.

By help of a camera placed on a 3-inch refractor, the speaker allowed the image of the sun—of about 4 inches in diameter—to fall upon the standard paper. The sun-picture thus obtained presents interesting features; in the first place, the chemical intensity of the central portions are 3–5 times as great as that of the portions on the limb. A difference of this kind, in the case of the luminous and calorific rays, has already been observed by astronomers, and it is doubtless caused by the absorption effected by the solar atmosphere.

The following results were obtained by measuring the chemical brightness at various points on the sun's disc, on May 9th, 1863; from these numbers it will be seen that the luminous intensity varies very irregularly.

CHEMICAL BRIGHTNESS OF SUN'S DISC.

1. At Centre of Sun's Disc.		2. 15° from Edge of Sun's Disc.			3. At the Edge of Sun's Disc.		
		N. Pole.	Equator.	S. Pole.	N. Pole.	Equator.	S. Pole.
No. 1.	100·0	38·8	48·4	58·1	18·7	30·2	28·2
No. 2.	100·0	52·8	—	56·6	30·5	—	41·0

Bright patches of considerable area were seen on the picture; these patches, which were not caused by irregularity in the paper or in the lenses, are probably owing to the presence of clouds in the luminous atmosphere of the sun, and they may probably have some intimate connection with the well-known phenomena of the red prominences seen during the solar eclipse.

The speaker concluded by stating that he hoped, with the assistance of his friend Mr. Baxendell, to make a series of regular observations of the variation of the chemical intensities of many points on the sun's surface.

[H. E. R.]

WEEKLY EVENING MEETING,

Friday, May 29, 1863.

COLONEL PHILIP JAMES YORKE, F.R.S. in the Chair.

PROFESSOR MAX MÜLLER,

On the Vedas, or the Sacred Books of the Hindus.

ROFESSOR MAX MÜLLER began by exhibiting four volumes of his lition of the text of the *Rig-Veda*, together with the commentary of áyanácharya. He stated that his attention had first been drawn to e importance of this work when attending, in the years 1846 and 847, the lectures of the late Eugène Burnouf at the Collège de rance. It was Burnouf, together with Dr. Goldstücker, now Prossor of Sanskrit at University College, who encouraged him to ndertake the task of editing the *Rig-Veda*—a work which had never een printed before either in India or in Europe, though it occupies the history of Sanskrit literature the same position which the Old estament occupies in the history of the Jews, the New Testament in e history of modern Europe, the Koran in the history of Mohamedanism. After collecting the necessary materials at Paris, in the ibrary of the East India House in London, and in the Bodleian ibrary at Oxford, he was enabled, through the patronage of the East ndia Company, to publish the first volume in 1849, the second in 853, and the third in 1856. After the extinction of the political owers of the East India Company, Government continued to sanction e grant, and Her Majesty accepted the dedication of the fourth olume, published in 1862. This edition of the *Rig-Veda* contains, sides the original text of the sacred hymns of the Brahmans, a comentary in Sanskrit by Sáyanácharya. This learned theologian wrote bout 1400 A.D., whereas the ancient hymns which he professes to xpound are referred to the fourteenth century B.C. His commentary a vast compilation from earlier works, some of which—as, for stance, the *Glosses* of Yáska—date from the sixth century B.C.

Veda, the name given by the Brahmans to the whole of their sacred terature, means originally *knowing*, or *knowledge*, and is derived from e same root which appears in the Greek *οἶδα*, I know, the Gothic *it*, I know; the English *to wit* and *wise*. It is considered, according the theological views of the Brahmans, to have been divinely reealed, and is distinguished under the name of *S'ruti* (literally *hearing*) om all other works, which, however sacred and authoritative, are mitted to have been composed by human authors, and are comprended under the name of *Smriti*, or tradition. The *Laws of Manu*, r instance, are considered only as Smriti, and if on any point they uld be proved to be at variance with a single passage of the *Veda* they would at once be overruled. In no country has the theory of revelation been so minutely elaborated as in India; and in order to exclude as much as possible the human element, which, in the perception of divine truth by a human understanding, must come in at some point or other, the Brahmans imagined a graduated scale of beings intermediate between the divine and the human, participating less and less in the divine, and more and more in the human nature, till at last the original perception or vision of the inspired Rishis had reached a purely human level, and had, without loss or injury, become the property of ordinary mortals. The *Veda*, however, was not allowed to enjoy for any length of time the undisturbed possession of these carefully elaborated claims. The Buddhists and many other heretical sects sprang up and denied the divine character of the *Vedas*, as well as the sacred privileges of the Brahmans, which rested on the authority of these works. They attacked the *Vedas* as "the incoherent rhapsodies of knaves and buffoons;" they denied "that there was any agreement among the learned in the interpretation of revelation and tradition;" and they pointed to passages which even the Brahmans themselves had been obliged to admit as meaningless or as interpolated. In the third century B.C. Buddhism became the state religion of India in the place of Brahmanism, and the Buddhists then claimed the same inspired character for their own sacred books which the founders of the religion of Buddha had so violently attacked when claimed by the Brahmans in favour of the *Veda*. About the seventh century A.D. a reaction took place. Buddhism had to yield to Brahmanism, and at the present moment there is no Buddhist left in India Proper; while the orthodox Hindu again believes that the *Vedas* were an immediate revelation granted before the beginning of time to certain inspired saints, and containing all that is necessary to his salvation.

The *Veda* is not one single book. It comprises four collections of hymns, called the Sanhitás of the *Rig-Veda*, the *Yajur-Veda*, the *Sáma-Veda*, and the *Atharva-Veda*. The *Atharva-Veda*, though it contains fragments of ancient poetry, is a collection of more modern date. It contains chiefly incantations, magic spells, propitiatory hymns, and large extracts from the other *Vedas*. The earliest authorities speak only of three *Vedas*, which are called the *Trayí* or *Triad*. Among these, again, a great distinction must be made between the *Rig-Veda* on the one side and the *Yajur* and *Sáma Vedas* on the other. The last two collections of hymns are mere prayer-books, arranged according to the order of certain sacrifices, and intended to be used by certain classes of priests:—the *Rig-Veda* is an historical collection. There are four classes of priests required for the performances of great sacrifices. The first comprises the *Adhvaryus*, or manual labourers who have to prepare the sacrificial ground, to dress the altar, and slay the victim. These, as being less educated, are only required to mutter certain hymns and formulas, which hymns and formulas in the order in which they are to be recited, are put together in what is called the Sanhitá of the *Yajur-Veda*. The *Udgátars*, or choristers, form the second class, and the hymns which they have to chant are again put together in proper order in the Sanhitá of the *Sáma-Veda.* But while the hymns to be muttered and chanted by these two classes of priests have been carefully collected in two breviaries, the poetical portions, which had to be recited by a third class, the *Hotars*, were not reduced to the same form, but the *Hotars* had to learn by heart the whole of the ancient sacred poetry that had been saved by oral tradition, and incorporated in the books of the *Rig-Veda.* Many of these poems were never intended for sacrificial purposes, and the *Hotars* had, therefore, to learn from their sacrificial manuals which of these hymns and verses had to be employed by them at certain parts of the sacrifices, while, at the same time, they became the depositaries of the whole of the popular and sacred poetry of their ancestors. Nearly all the poetical portions which the other two classes of priests have to mutter or to chant are to be found in the *Rig-Veda*, which is therefore to us the *Veda par excellence*, and the only document in the earliest literature of India which can claim an historical character. The fourth class of priests are the Brahmans, properly so called, the overseers of the whole sacrifice, who, while they generally remain silent spectators, have only to interfere when any mistake has been committed. They must be acquainted with the duties of the other three classes of priests, and they derive their knowledge chiefly from large prose treatises—hence called the *Bráh·man·as*, or the books of the Brahmans—in which the ritual is explained in full detail, and old sayings are preserved to illustrate the origin and the mysterious meaning of every part of the Vedic sacrifices.

The *Rig-Veda*—a collection resembling the Psalms, and, in some respects, the *Percy Relics*—is divided into ten books or *Mandalas*, each supposed to have been the property of one of the great Brahmanic families of India. It has been preserved to the present day by oral tradition as well as by manuscripts. Manuscripts, however, are in India of very modern date; and if the *Rig-Veda* claims to be the oldest book in the literature of the Aryan race—older than Homer, the Zendavesta, the Cuneiform Inscriptions, Ennius, or Ulfilas—we want strong arguments in support of such claims. The speaker stated that he had himself entertained grave doubts as to the antiquity of the *Veda*, and that its preservation during a thousand years by means of oral tradition only was enough to stagger those who were acquainted merely with the literary history of Greece and Rome. Yet it is a fact that, even at present, candidates for orders in India learn the *Rig-Veda* by heart, not from MSS., but from the mouth of a *Guru* under whose direction they spend the whole of their youth from the eighth to the thirtieth year. They do nothing else during all that time but learn by heart; and if we want to know how accurately the human memory can retain a whole literature—more accurately, in fact, than either paper or parchment—India, even at the present day, with the old system of Brahmanic discipline relaxed and breaking up, will furnish the most startling evidence. That the *Veda* is not quite a modern forgery can be proved by *The Travels of Hiouen-thsang*, a Buddhist pilgrim who travelled from China to India in the years

629–645, and who, in his diary translated from Chinese into French by Stanislas Julien, gives the names of the four *Vedas*, mentions some grammatical forms peculiar to the Vedic Sanskrit, and states that at his time young Brahmans spent all their time, from the seventh to the thirtieth year of their age, in learning these sacred texts. At the time when Hiouen-thsang was travelling in India, Buddhism was clearly on the decline. But Buddhism was originally a reaction against Brahmanism, and chiefly against the exclusive privileges which the Brahmans claimed, and which from the beginning were represented by them as based on their revealed writings, and hence beyond the reach of human attacks. Buddhism, whatever the date of its founder, became the state religion of India under Aśoka, the Constantine of India, in the middle of the third century B.C. This Aśoka was the third king of a new dynasty founded by Chandragupta, the well-known contemporary of Alexander and Seleucus, about 315 B.C. The preceding dynasty was that of Nandas, and it is under that dynasty that the traditions of the Brahmans place a number of distinguished scholars whose treatises on the *Veda* we still possess. Thus, in the same manner as the Septuagint translation proves the existence of the Old Testament during the third century B.C., although the oldest Hebrew MSS. date only from the tenth century after Christ, so the works of Kátyáyana in the fourth century B.C., which give us the number of the hymns, the verses, words, and syllables of the *Rig-Veda*, prove that at this time the *Veda* existed in exactly the same form in which we possess it. The number of hymns is 1028, that of the verses varies from 10,402 to 10,622, that of the words is 153,826, that of the syllables, 432,000. These Rabbinical studies on the *Veda* seem to date from about 600 B.C., and they are embodied in works called *Sûtras* or threads, all composed in the most brief, enigmatic, and almost algebraic style. This literature of *Sûtras* is preceded by another class of writings, the *Brâhmanas*, composed in a very prolix and tedious style, and containing lengthy lucubrations on the sacrifices and on the duties of the different classes of priests. Each of the three or four Vedas, or each of the three or four classes of priests, has its own *Brâhmanas* and its own *Sûtras*; and as the *Brâhmanas* are presupposed by the *Sûtras*, while no *Sûtra* is ever quoted by the *Brâhmanas*, it is clear that the period of *Brâhmana* literature must have preceded the period of the *Sûtra* literature. There are, however, old and new *Brâhmanas*, and there are in the *Brâhmanas* themselves long lists of teachers who handed down old Brâhmanas or composed new ones, so that it seems impossible to accommodate the whole of that literature in less than two centuries, from about 800 to 600 B.C. Before, however, a single *Brâhmana* could have been composed, it was not only necessary that there should have been one collection of ancient hymns, like that contained in the ten books of the *Rig-Veda*, but the three or four classes of priests must have been established, the manual labourers and the choristers must have had their special prayer-books, and these prayer-books must have undergone certain changes, because the *Brâhmanas* presuppose different editions or *sâkhâs* of each rayer-book. Professor Müller supposes that the work of collecting he prayers for the different classes of priests, and of adding new ymns and formulas for purely sacrificial purposes, belonged to the enth century B.C., and that three generations more would be required o account for the various readings adopted in the prayer-books by ifferent sects, and invested with a kind of sacred authority previously o the composition of even the earliest among the *Brâhmanas.* If herefore the years from about 1000 to 800 B.C. are assigned to this ollective age, the time before 1000 B.C. must be set apart for the free nd natural growth of what was then national and religious, but not yet acred and sacrificial poetry. How far back this period extends it is mpossible to tell; it is enough if the hymns of the *Rig-Veda* can be raced to 1000 B.C.

Much in the chronological arrangement of the three periods of Vedic iterature that are supposed to have followed after that of the original rowth of the hymns must of necessity be hypothetical, and has been put orward rather to invite than to silence criticism. In order to discover ruth, the speaker remarked, we must be truthful ourselves, and must elcome those who point out our errors as heartily as those who aprove and confirm our discoveries. What seems, however, to speak trongly in favour of the historical character of the three periods of Vedic iterature is the uniformity of style which marks the productions of each. n modern literature we find, at one and the same time, different styles f prose and poetry cultivated by one and the same author. A Goethe rites tragedy, comedy, satire, lyrical poetry, and scientific prose; ut we find nothing like this in primitive literature. The individual there much less prominent, and the poet's character disappears in he general character of the layer of literature to which he belongs. t is the discovery of such large layers of literature following each ther in regular succession which inspires the critical historian with onfidence in the truly historical character of the successive literary roductions of ancient India. As in Greece there is an epic age of terature, where we should look in vain for prose or dramatic poetry; in that country we never meet with real elegiac poetry before the nd of the eighth century, nor with iambics before the same date; even in more modern times rhymed heroic poetry sets in in England ith the Norman conquest, and in Germany the Minnesänger rise and t with the Swabian dynasty—so, only in a much more decided manner, e see in the ancient and spontaneous literature of India, an age of oets followed by an age of collectors and imitators, that age to be ucceeded by an age of theological prose writers, and this last by an ge of writers of scientific manuals. New wants produced new supplies, nd nothing sprang up or was allowed to live, in prose or poetry, except hat was really wanted. If the works of poets, collectors, imitators, eologians, and teachers were all mixed up together—if the *Brâhmanas* uoted the *Sûtras*, and the hymns alluded to the *Brâhmanas*—an istorical restoration of the Vedic literature of India would be lmost an impossibility. We should suspect artificial influences, d look with small confidence on the historical character of such a literary agglomerate. The exact age of the *Veda* may be scarcely less difficult to determine than that of the jawbone of Abbeville; but he who would question its antiquity must explain how the layers of literature were formed that are super-imposed over the original stratum of the poetry of the Rishis; he who would suspect a literary forgery must show how, when, and for what purpose the 1000 hymns of the *Rig-Veda* could have been forged, and have become the basis of the religious, moral, political, and literary life of the ancient inhabitants of India.

Professor Müller concluded by reading some extracts from the *Rig-Veda*, and referred his audience to the second edition of his *History of Ancient Sanskrit Literature* for further information on the subject. He pointed out that the work of translating, or rather deciphering, the whole of the *Rig-Veda* would require many more years, and could only be achieved by the active co-operation of many scholars. The chief results hitherto obtained from the discovery of the Vedic literature of India consist in the new and unexpected light which has suddenly been shed on the earliest and darkest periods in the growth of the human mind. The true and natural sources of religious faith have been laid bare; and the original character of polytheism, and the spread of mythological phraseology among the ancestors of the Aryan race, have ceased to be matters of mere speculation, and have entered into the domain of historical research. As a relic of this earliest age in the history of language and religion, the *Veda* stands unparalleled in the literature of the whole Aryan race. What in Homer and Hesiod appears as a distant past is here still present, and the childhood of our race is revealed to our eyes once more in clear and simple outlines. A result still more important is the help which missionaries in India have derived from the publication of the *Veda* in their intercourse with the most learned and most influential among the Brahmans. As long as the *Veda* was unpublished, the Brahmans maintained that whatever the missionaries told them was contained in their *Vedas*. Now, the missionary can ask for chapter and verse, and refute the Brahmans from their own bible. To attack Brahmanism without a knowledge of the *Veda* was like attacking Mohammedanism without a knowledge of the Koran. The speaker finished by expressing his conviction that no country is so ripe for the introduction of genuine Christianity as India. There are many things in the *Veda* which, if properly explained, the Brahmans should be allowed, nay encouraged, to hold fast. But the present state of popular religion in India is a mere anachronism, and an insult to the memory of the great religious teachers whom India produced in the days of her greatness. The most earnest and thoughtful among the Brahmans have themselves begun to feel this; and the conversion of one such man as the excellent Nilakantha Goreh, the son of one of the most influential Brahmans at Benares—a man who sacrificed everything for the sake of Christ—is a sign of the times that ought to be as encouraging to our missionaries abroad and their friends at home as the conversion of Saul and the sufferings of the early Martyrs.

[M. M.]

GENERAL MONTHLY MEETING.

Monday, June 1, 1863.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

His Royal Highness the Prince Louis of Hesse,

was unanimously elected an Honorary Member of the Royal Institution.

William Barnet, Esq.
Joseph Goulden, Esq.
George Johnson, M.D.
George Prevost, Esq.
George Henry Strutt, Esq.
Miss Elizabeth Woods

were *elected* Members of the Royal Institution.

John Graham, M.D.
John Hogg, Esq. M.A. F.R.S. and
Cosmo R. Howard, Esq.

were *admitted* Members of the Royal Institution.

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From
American Philosophical Society—Transactions. New Series. Vol. XII. Part 3. 4to. 1863.
Anthropological Society—The Anthropological Review, No. I. 8vo. 1863.
Ansted, D. T. Esq., M.A. F.R.S. (the Author)—The Correlation of the Natural History Sciences. (O 11) 16to. 1863.
Astronomical Society, Royal—Monthly Notices, No. 6. 8vo. 1863.
Asiatic Society of Bengal—Journal, No. 288. 8vo. 1862.
Asiatic Society, Royal—Journal, Vol. XX. Part 2. 8vo. 1863.
Author, The—The New Testament and the Pentateuch, with Remarks upon the Inspiration of the Bible, occasioned by the Colenso Controversy. 16to. 1863.
British Meteorological Society—Proceedings, No. 7. 8vo. 1863.
Chambers, George F. Esq. M.R.I.—Working of the New Beer Act (of 1854). (K 89) 8vo. 1863.
Chemical Society—Quarterly Journal, New Series, No. 5. 8vo. 1863.
Civil Engineers, Institution of—Proceedings, May, 1863. 8vo.
Dublin Society, Royal—Journal, No. 29. 8vo. 1863.
Editors—American Journal of Science, by B. Silliman, &c. for 1862. 8vo.
  Artizan for May, 1863. 4to.
  Athenæum for May, 1863. 4to.
  Chemical News for May, 1863. 4to.
  Engineer for May, 1863. fol.

Editors (continued)—Horological Journal, No. 37. 4to.
Journal of Gas-Lighting for May, 1863. 4to.
Mechanics' Magazine for May, 1863. 8vo.
Medical Circular for May, 1863. 8vo.
Practical Mechanics' Journal for May, 1863. 4to.
Technologist for May, 1863. 8vo.
Franklin Institute of Pennsylvania—Journal, No. 448. 8vo. 1863.
Geological Institute, Vienna—General Register to Band 1-10 of the Jahrbuch. 4to. 1863.
Geological Society—Quarterly Journal, No. 74. 8vo. 1863.
Horticultural Society, Royal—Proceedings, 1862. No. 5. 8vo.
Holland, Sir Henry, Bart. M.D. F.R.S. M.R.I.—Documents relative to the History of the State of New York, procured in Holland, England, and France. (With Index.) 11 vols. 4to. 1856-8.
Jevons, W. S. Esq. (the Author)—A Serious Fall in the Value of Gold ascertained. (K 89) 8vo. 1863.
Jones, Sir Willoughby, Bart. M.R.I. (the Author)—Christianity and Common Sense. 8vo. 1863.
Leighton, John, Esq. F.S.A. M.R.I. (the Author)—On Japanese Art. fol. 1863.
Linnean Society—Proceedings, No. 26. 8vo. 1863.
Newton, Messrs.—London Journal (New Series) for May, 1863. 8vo.
Petermann, A. Esq. (the Editor)—Mittheilungen aus dem Gesammtgebiete der Geographie. 1863. No. 4. 4to.
United States Naval Observatory, Washington—Astronomical and Meteorological Observations in 1861. 4to. 1862.
Yates, James, Esq. F.R.S.—The Rev. J. Kerr: The Metric System: its Prospects in this Country. (K 89) 8vo. 1863.
Zoological Society of London—Transactions, Vol. IV. Part 7. Vol. V. Parts 1 and 2. 4to. 1862-3. Proceedings: 1861, Part 3. 1862, Parts 1, 2, 3. 8vo.

Crookes, William, Esq.—Ingot of Thallium.
Hills, T. H. Esq.—Piece of Wood containing Teredo Worms.

WEEKLY EVENING MEETING,

Friday, June 5, 1863.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

JOHN RUSKIN, Esq.

On the Forms of the Stratified Alps of Savoy.

THE purpose of the discourse was to trace some of the influences which have produced the present external forms of the stratified mountains of Savoy, and the probable extent and results of the future operation of such influences.

The subject was arranged under three heads :—

I. The Materials of the Savoy Alps.
II. The Mode of their Formation.
III. The Mode of their subsequent Sculpture.

I. *Their Materials.*—The investigation was limited to those Alps
h consist, in whole or in part, either of Jura limestone, of Neoco-
n beds, or of the Hippurite limestone, and include no important
es of other formations. All these rocks are marine deposits; and
first question to be considered with respect to the development of
ntains out of them, is the kind of change they must undergo in
g dried. Whether prolonged through vast periods of time, or
ened by heat and pressure, the drying and solidification of such
s involved their contraction, and usually, in consequence, their
g traversed throughout by minute fissures. Under certain con-
ons of pressure, these fissures take the aspect of slaty cleavage;
er others, they become irregular cracks, dividing all the substance
the stone. If these are not filled, the rock would become a mere
p of debris, and be incapable of establishing itself in any bold form.
s is provided against by a metamorphic action, which either arranges
particles of the rock, throughout, in new and more crystalline con-
ons, or else causes some of them to separate from the rest, to
erse the body of the rock, and arrange themselves in its fissures;
s forming a cement, usually of finer and purer substance than the
of the stone. In either case the action tends continually to the
ification and segregation of the elements of the stone. The energy
uch action depends on accidental circumstances. First, on the
ctions of the component elements among themselves; secondly,
very change of external temperature and relation. So that moun-
s are at different periods in different stages of health (so to call it)
isease. We have mountains of a languid temperament, mountains
checked circulations, mountains in nervous fevers, mountains in
phy and decline.

This change in the structure of existing rocks is traceable through
inuous gradations, so that a black mud or calcareous slime is im-
eptibly modified into a magnificently hard and crystalline substance,
sing nests of beryl, topaz, and sapphire, and veined with gold.
it cannot be determined how far, or in what localities, these changes
yet arrested; in the plurality of instances they are evidently yet
ogress. It appears rational to suppose that as each rock approaches
s perfect type the change becomes slower; its perfection being
inually neared, but never reached; its change being liable also to
ruption or reversal by new geological phenomena. In the process
is change, rocks expand or contract; and, in portions, their multi-
ous fissures give them a ductility or viscosity like that of glacier-
n a larger scale. So that many formations are best to be con-
d as glaciers, or frozen fields of crag, whose depth is to be measured
iles instead of fathoms; whose crevasses are filled with solvent

flame, with vapour, with gelatinous flint, or with crystallizing elements of mingled natures; the whole mass changing its dimensions and flowing into new channels, though by gradations which cannot be measured, and in periods of time of which human life forms no appreciable unit.

II. *Formation.*—Mountains are to be arranged, with respect to their structure, under two great classes—those which are cut out of the beds of which they are composed, and those which are formed by the convolution or contortion of the beds themselves. The Savoy mountains are chiefly of this latter class. When stratified formations are contorted, it is usually either by pressure from below, which raises one part of the formation above the rest; or by lateral pressure, which reduces the whole formation into a series of waves. The ascending pressure may be limited in its sphere of operation; the lateral one necessarily affects extensive tracts of country, and the eminences it produces vanish only by degrees, like the waves left in the wake of a ship. The Savoy mountains have undergone both these kinds of violence in very complex modes and at different periods, so that it becomes almost impossible to trace separately and completely the operation of any given force at a given point.

The speaker's intention was to have analyzed, as far as possible, the action of the forming forces in one wave of simple elevation, the Mont Salève; and in another of lateral compression, the Mont Brezon: but the investigation of the Mont Salève had presented unexpected difficulty. Its façade had been always considered to be formed by vertical beds, raised into that position during the tertiary periods: the speaker's investigations had, on the contrary, led him to conclude that the appearance of vertical beds was owing to a peculiarly sharp and distinct cleavage, at right angles with the beds, but nearly parallel to their strike, elsewhere similarly manifested in the Jurassic series of Savoy, and showing itself on the fronts of most of the precipices formed of that rock. The attention of geologists was invited to the determination of this question.

The compressed wave of the Brezon, more complex in arrangement, was more clearly defined. A section of it was given, showing the reversed position of the Hippurite limestone in the summit and lower precipices. This limestone wave was shown to be one of a great series, running parallel with the Alps, and constituting an undulatory district, chiefly composed of chalk beds, separated from the higher limestone district of the Jura and lias by a long trench or moat, filled with members of the tertiary series—chiefly nummulite limestones and flysch. This trench might be followed from Faverges, at the head of the lake of Annecy, across Savoy. It separated Mont Vergi from the Mont Dorons, and the Dent d'Oche from the Dent du Midi; then entered Switzerland, separating the Moleson from the Diablerets; passed on through the districts of Thun and Brientz, and, dividing itself into two, caused the zigzagged form of the lake of Lucerne. The principal branch then passed between the high Sentis and the Glarnisch, and oke into confusion in the Tyrol. On the north side of this trench the alk beds were often vertical, or cast into repeated folds, of which the carpments were mostly turned away from the Alps; but on the uth side of the trench, the Jurassic, Triassic, and Carboniferous beds, ough much distorted, showed a prevailing tendency to lean towards e Alps, and turn their escarpments to the central chain.

Both these systems of mountains are intersected by transverse valleys, ring their origin, in the first instance, to a series of transverse curvi- ear fractures, which affect the forms even of every minor ridge, and oduce its principal ravines and boldest rocks, even where no distinctly cavated valleys exist. Thus, the Mont Vergi and the Aiguilles of llouvre are only fragmentary remains of a range of horizontal beds, ice continuous, but broken by this transverse system of curvilinean eavage, and worn or weathered into separate summits.

The means of this ultimate sculpture or weathering were lastly to considered.

III. *Sculpture.*—The final reductions of mountain form are owing ther to disintegration, or to the action of water, in the condition of in, rivers, or ice; aided by frost and other circumstances of tem- erature and atmosphere.

All important existing forms are owing to disintegration, or the ction of water. That of ice had been curiously overrated. As an strument of sculpture, ice is much less powerful than water: the ap- arently energetic effects of it being merely the exponents of disintegra- ion. A glacier did not produce its moraine, but sustained and exposed he fragments which fell on its surface, pulverizing these by keeping hem in motion, but producing very unimportant effects on the rock elow; the roundings and striation produced by ice were superficial; hile a torrent penetrated into every angle and cranny, undermining nd wearing continually, and carrying stones, at the lowest estimate, six undred thousand times as fast as the glacier. Had the quantity of rain hich has fallen on Mont Blanc in the form of snow, (and descended in he ravines as ice,) fallen as rain, and descended in torrents, the ravines ould have been much deeper than they are now, and the glacier may o far be considered as exercising a protective influence. But its power f carriage is unlimited, and when masses of earth or rock are once oosened, the glacier carries them away, and exposes fresh surfaces. enerally, the work of water and ice is in mountain surgery like that f lancet and sponge—one for incision, the other for ablution. No xcavation by ice was possible on a large scale, any more than by a tream of honey; and its various actions, with their limitations, were nly to be understood by keeping always clearly in view the great law f its motion as a viscous substance, determined by Professor James orbes.

The existing forms of the Alps are, therefore, traceable chiefly to enudation as they rose from the sea, followed by more or less violent queous action, partly arrested during the glacial periods, while the produced diluvium was carried away into the valley of the Rhine or into the North Sea. One very important result of denudation had not yet been sufficiently regarded; namely, that when portions of a thick bed (as the Rudisten-kalk) had been entirely removed, the weight of the remaining masses, pressing unequally on the inferior beds, would, when these were soft (as the Neocomian marls), press them up into arched conditions, like those of the floors of coal-mines in what the miners called "creeps." Many anomalous positions of the beds of Spatangen-kalk in the district of the Lake of Annecy were in all probability owing to this cause: they might be studied advantageously in the sloping base of the great Rochers de Lanfon, which, disintegrating in curved, nearly vertical flakes, each a thousand feet in height, were nevertheless a mere outlying remnant of the great horizontal formation of the Parmelan, and formed, like it, of very thin horizontal beds of Rudisten-kalk, imposed on shaly masses of Neocomian, modified by their pressure. More complex forms of harder rock were wrought by the streams and rains into fantastic outlines; and the transverse gorges were cut deep where they had been first traced by fault or distortion. The analysis of this aqueous action would alone require a series of discourses; but the sum of the facts was that the best and most interesting portions of the mountains were just those which were finally left, the centres and joints as it were of the Alpine anatomy. Immeasurable periods of time would be required to wear these away; and to all appearances, during the process of their destruction, others were rising to take their place, and forms of perhaps far more nobly-organized mountain would witness the collateral progress of humanity.

[J. R.]

WEEKLY EVENING MEETING,

Friday, June 12, 1863.

Rev. John Barlow, M.A. F.R.S. Vice-President, in the Chair.

John Tyndall, Esq. F.R.S.

PROFESSOR OF NATURAL PHILOSOPHY, ROYAL INSTITUTION.

An Account of some Researches on Radiant Heat.

In his former researches on the radiation and absorption of heat by gaseous matter, the speaker compared different gases and vapours at a common thickness with each other; one part of his present object was to compare different thicknesses of the same gaseous body with each ther as to their action upon radiant heat. A few years ago he would be deemed a bold man who would attempt to measure the action of an inch, or indeed of many feet of a gas, on radiant heat; but the present experiments commence with plates of gas only 0·01 of an inch in thickness, and extend to thicknesses of 49·4 inches. Thus, the greatest thickness is to the least nearly in the ratio of 1 to 5000. The apparatus employed for the smaller thicknesses was a hollow cylinder, one end of which was closed by a plate of rock-salt. Into this fitted a second cylinder, with its end also closed by a plate of the salt. One cylinder moved within the other like a piston, and by this means the two plates of salt could be brought into flat contact with each other, or could be separated to any required distance. The distance between the plates was measured by a *vernier*. The cylinder was placed horizontal, being suitably connected with a source of heat. This latter consisted of a plate of copper, against which a steady sheet of flame was caused to play.

The absorption of radiant heat by carbonic oxide, carbonic acid, nitrous oxide, and olefiant gas was determined with this apparatus, and such differences as might be anticipated from former researches were found. Olefiant gas maintained its great superiority over the other gases at all thicknesses. A layer of this gas, not more than 0·01 of an inch in thickness, intercepted about 1 per cent. of the total radiation; and the delicacy of the apparatus may be inferred from the fact that this absorption—great, relative to the thickness of the layer of gas, but small absolutely—corresponded to a deflection of 11 degrees of the galvanometer. (It would be certainly possible to measure the action of a layer of this gas of less thickness than the paper on which these words are printed.) A layer of olefiant gas, 2 inches in thickness, intercepts nearly 30 per cent. of the entire radiation. The influence of a diathermic envelope surrounding a planet may be strikingly illustrated by reference to this gas. A shell of olefiant gas, 2 inches thick, surrounding the earth, would offer no appreciable hindrance to the solar rays in their earthward course; but it would intercept, and in great part return, 30 per cent. of the terrestrial radiation: under such a canopy the surface of the earth would probably be raised to a stifling temperature. A layer of the gas, 3-10ths of an inch thick, intercepts 11·5 per cent. of the whole radiation. Such a layer, if diffused through a stratum of air 10 feet thick, would be far more attenuated than the aqueous vapour actually diffused through the air; still it would produce an absorption greater than that which the speaker had assigned to the atmospheric vapour within 10 feet of the earth's surface. In the presence of such facts, the arguments which we might be disposed to base on the smallness of the quantity of atmospheric vapour are entirely devoid of weight.

In measuring the action of larger thicknesses of gas, the following method was pursued:—A brass cylinder, 49·4 inches in length, had its two ends stopped with plates of rock salt, and a suitable source of heat placed at one end; the rays from this source passed through the tube, and were received by a thermo-electric pile placed at its opposite end; this radiation was exactly neutralized by the heat emitted from a cube of boiling water and incident on the opposite face of the pile. The interception of any portion of the heat emanating from the source by a gas or vapour introduced into the tube destroyed the equilibrium previously existing, and the amount intercepted was declared by the galvanometer. The thickness traversed by the calorific rays was varied in the following way:—The tube was divided into two distinct compartments by the introduction of a third plate of rock salt. Let us agree to call the compartment most distant from the pile the *first chamber*, and that adjacent to the pile the *second chamber*. The experiments began with the first chamber short and the second chamber long, and ended with the first chamber long and the second chamber short. The alteration consisted solely in the shifting of the intermediate plate of salt, which lengthened the first chamber and diminished the second one by the same quantity; the sum of the lengths of both chambers being the constant quantity, 49·4 inches.

The absorption effected in the first chamber acting alone was first determined; then the absorption effected in the second chamber acting alone; and, finally, the absorption effected when both the chambers were occupied by the gas or vapour. This arrangement enabled the speaker to check his experiments, and also to examine the effect of the *sifting* which occurred in the first chamber on the absorption of the second one. The thermal coloration of the various gases was rendered strikingly manifest by these experiments. For the vast majority of the rays, for example, carbonic oxide and carbonic acid are transparent. Placing a stratum of carbonic oxide, 8 inches in length, in front of a column of the same gas, 41·4 inches long, these 8 inches intercepted 6 per cent. of the whole radiation; placed *behind* a column, 41·4 inches long, the absorption of the same 8 inches was sensibly *nil*. So also with carbonic acid; 8 inches in front absorbed 6¼ per cent., while placed behind the effect was almost zero. Similar remarks apply to the other gases, the reason manifestly being that when the 8-inch stratum is in front, it stops the main portion of the rays which give it its thermal colour, while, when it is placed behind, these same rays have been almost wholly withdrawn, and to the remaining 94 per cent., or thereabouts, of the radiation the gases are sensibly transparent.

An extension of this reasoning enables us at once to conclude, that the sum of the absorptions of the two chambers taken separately must always be greater than the absorption effected by a single column of the gas of a length equal to the sum of the two chambers. This conclusion is illustrated in a striking manner by the experiments; and it is further found that when the mean of the sums of the absorptions is divided by the absorption of the sum, the quotient is sensibly the same for all gases. It may also be inferred from considerations similar to the foregoing, that the sum of the absorptions must diminish, and approximate to the absorption of the sum, as the two chambers become more unequal in length, and that the sum of the absorptions of the two chambers is a maximum, when the medial rock-salt plate divides the long tube into two equal compartments.

In these days a special interest attaches itself to the radiation of any gas through itself or through any other gas having the same period of vibration. The speaker referred to the results of an elaborate series of experiments on this interesting question. The experimental tube, 49·4 inches long, was divided into two compartments by a partition of rock-salt. All external sources of heat were abolished, and the pile, furnished with its conical reflector, stood at the end of the tube. The compartment nearest the pile contained the gas which was to act as absorber, while that most distant from the pile held the gas which was to act as radiator. It is known that the destruction of the motion of a sensible mass of matter is always accompanied by the evolution of heat. A weight falling to the earth, and a ball striking a target, are heated on collision. The same is true for atoms, and in the present experiments the gas in the radiating chamber was heated by the collision of its own particles against the inner surface of the tube when they rushed in to fill the vacuum. The radiation was, in fact, what the speaker had named "dynamic radiation." The lengths of the two chambers were varied, the radiating column being lengthened and the absorbing one shortened at one and the same time; the sum of both was always the constant length 49·4 inches.

The experiments with the vapours were thus executed. Both the chambers into which the tube was divided were, in the first place, occupied by the vapour to be examined; the usual pressure being 1-60th of an atmosphere. The entrance of the vapour was so slow, and its quantity so small, that the radiation due to the warming of the vapour by its own collision was insensible. The needle being at zero, dry air was allowed to enter the chamber most distant from the pile. This air became heated dynamically, communicated its heat to the vapour, and the latter immediately discharged the heat thus communicated to it against the pile. It is quite evident, that not only does this case resemble, but that it is actually of the same mechanical character as that in which a vibrating tuning-fork is brought into contact with a surface of some extent. The fork, which before was inaudible, becomes at once a copious source of sound. What the sounding-board is to the fork, the compound molecule is to the elementary atom. The tuning-fork vibrating alone is in the condition of the atom radiating alone, the sound of the one and the heat of the other being alike insensible. But in association with sulphuric or acetic ether-vapour the elementary atom is in the condition of the tuning-fork applied to its sound-board, communicating through the molecule motion to the luminiferous ether, as the fork through the board communicates its motion to the air.

The experiments demonstrate the great opacity of a gas to radiations from the same gas. They also show in a very striking manner the influence of attenuation in the case of vapour. The individual molecules of a vapour may be powerful absorbers and radiators, but in thin strata they constitute an open sieve through which a large quantity of radiant heat may pass. In such thin strata, therefore, the vapours, as used in our experiments, were generally found far less energetic than the gases, while in thick strata the same vapours showed an energy greatly superior to the same gases. The gases, it will be remembered, were always employed at a pressure of one atmosphere.

A few striking experiments were referred to in illustration of the influence of a paper lining, or a coat of varnish or lampblack, within the experimental tube. In dynamic radiation it is not possible to do entirely away with the action of the interior surface of the tube itself. When the tube is of brass and well polished within, the entrance of the air produces a deflection of 7·5 degrees, this being due to the emission from the warmed surface of the tube. A lining of paper two feet long raises the radiation sufficiently to drive the needle through an arc of 80 degrees, while a ring of paper 1½ inches long placed within the tube radiates sufficient to urge the needle through an arc of 56 degrees.

The speaker finally examined the diathermancy of the liquids from which his vapours were derived, and the result leaves no shadow of a doubt upon the mind, that both absorption and radiation are molecular phenomena, irrespective of the state of aggregation. If any vapour is a strong absorber and radiator, the liquid whence it comes is also a strong absorber and radiator. The molecule carries its power, or want of power, through all its states of aggregation. The order of absorption in liquids and vapours is precisely the same; and the speaker looked forward with hope to the application of these results to other portions of the domain of thermotics.

[J. T.]

EXTRA EVENING MEETING,

Tuesday, June 23, 1863.

H.R.H. The Prince of Wales, Vice-Patron, in the Chair.

Capt. Speke,

On the Discovery of the Source of the Nile.

[No Abstract received.]

GENERAL MONTHLY MEETING,

Monday, July 6, 1863.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

General Theophilus Boileau, F.R.S.
Charles Hewitt Moore, Esq.

were *elected* Members of the Royal Institution.

The Secretary read the following communication from H.R.H. The Prince Louis of Hesse:—

"Jagdschloss, Kranichstein,
near Darmstadt, June 19, 1863.

"Sir,—I have been commanded by His Royal Highness The Prince Louis of Hesse to acknowledge the receipt of your letter, in which you inform His Royal Highness of the election as an Honorary Member of the Royal Institution.

"His Royal Highness has been very much flattered by this election, and hopes in accepting it, that during a future stay in England, His Royal Highness will find more opportunities to attend the lectures of the Royal Institution.

"I have the honour to be, Sir,
"Yours very faithfully,
"G. Westerweller.

"Dr. H. Bence Jones,
Honorary Secretary, R.I."

The Secretary announced, That a Member of the Royal Institution (who wished his name to be withheld) had presented the sum of Twenty Pounds, to be added to the Holland Fund. He also announced, that the Annual Donations of Sir Henry Holland, of Sir Roderick I. Murchison, and of Mr. S. R. Solly, for the purchase of Scientific Apparatus, would in future, with their consent, be incorporated in one fund, to be entitled, "The Donation Fund for the Promotion of Experimental Researches."

The Special Thanks of the Members were returned to E. Sonstadt, Esq. for his valuable present, through Professor Faraday, of three specimens of the metal Magnesium, in three different stages of manufacture, weighing respectively 2039, 139, and 41 grains.

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

American Journal of Natural Sciences—Proceedings, Nos. 1, 2. 8vo. 1863.
Transactions. New Series. Vol. XII. Part 3. 4to. 1863.
Asiatic Society of Bengal—Journal, No. 289. 8vo. 1863.
Astronomical Society, Royal—Monthly Notices, No. 7. 8vo. 1863.
Bavarian Academy, Royal—Sitzungsberichte, 1862. Band II. Heft 3 & 4. 1863. Band I. Heft 1 & 2. 8vo.
Beke, C. T. Ph. D. (the Author)—Who discovered the Sources of the Nile? (K 90) 8vo. 1863.
Belgique, Académie Royale de—Bulletins des Sciences. 1862. 8vo. 1863.
Almanach. 1863. 16to.
Catholic University of Ireland—The Atlantis. Nos. 7, 8. 8vo. 1863.
Chemical Society—Quarterly Journal, New Series, Nos. 6, 7. 8vo. 1863.
Colonial Emigration Society—Emigration to the British Colonies. (K 90) 8vo. 1863.
Cornwall Polytechnic Society, Royal—Thirtieth Annual Report: 1862. 8vo.
Dublin Geological Society—Journal, Vol. X. Part 1. 8vo. 1863.
Editors—Artizan for June, 1863. 4to.
Athenæum for June, 1863. 4to.
Chemical News for June, 1863. 4to.
Engineer for June, 1863. fol.
Horological Journal, No. 58, 59. 4to. 1863.
Journal of Gas-Lighting for June, 1863. 4to.
Mechanics' Magazine for June, 1863. 8vo.
Medical Circular for June, 1863. 8vo.
Practical Mechanics' Journal for June, 1863. 4to.
Technologist for June, 1863. 8vo.
Franklin Institute of Pennsylvania—Journal, No. 449. 8vo. 1863.
Garner, Robert, Esq. (the Author)—Figures illustrating the Structure of various Invertebrate Animals. (M 7) 8vo. 1860.
Geological Institute, Vienna—Jahrbuch, Band XIII. No. 1. 4to. 1863.
Horticultural Society, Royal—Proceedings, 1863. No. 6. 8vo.
Macilwain, George, Esq. M.R.I. (the Author)—Remarks on Ovariotomy. (A Postscript to his Work on Tumours.) 8vo. 1863.
Manning, Frederick, Esq. M.R.I.—Engraving of Dr. Donne's Monument in St. Paul's. [Inserted in Walton's Lives.]
Newton, Messrs.—London Journal (New Series) for June, 1863. 8vo.
Oliveira, Benjamin, Esq. F.R.S. M.R.I. (the Author)—On the Works of the Isthmus of Suez Canal, in April, 1863. (K 90) 8vo. 1863.
Petermann, A. Esq. (the Editor)—Mittheilungen aus dem Gesammtgebiete der Geographie. 1863. No. 5. 4to.
Photographic Society—Journal, No. 134. 8vo. 1863.
Royal Society of London—Proceedings, No. 53. 8vo. 1863.
Sillimans, Professors (the Editors)—American Journal of Science and Arts, No. 105. May, 1863. 8vo.
Stanford, Mr. E. (the Publisher)—Map of the Route explored by Captains Speke and Grant, from Zanzibar to Egypt, showing the Outfall of the Nile from the Victoria Nyanza Lake: Feb. 26, 1863.
Statistical Society—Journal, Vol. XXVI. Part 2. 8vo. 1863.
Taylor, the Rev. William, F.R.S. M.R.I.—A True Account and Declaration of the Horrid Conspiracy against the late King, &c. fol. 1685.
United Service Institution, Royal—Journal, No. 25, and Appendix. 8vo. 1863.
Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Jan. Feb. 1863. 4to.
Yates, James, Esq. F.R.S. M.R.I.—The Metric System: its Prospects in this country, by the Rev. John Kerr. (K 89) 8vo. 1863.

Royal Institution of Great Britain.

1863.

GENERAL MONTHLY MEETING.

Monday, November 2, 1863.

he Rev. J. **Barlow**, M.A. F.R.S. Vice-President, in the Chair.

Captain Douglas Galton, R.A. F.R.S.
Leonard Jaques, Esq.
William Noble, Esq.
The Hon. Josceline W. Percy.
Allan Roskell, Esq.
William Sterry, Esq.

elected Members of the Royal Institution.

George Henry Strutt, Esq.

admitted a Member of the Royal Institution.

he Secretary announced the following additions to "the Donation d for the Promotion of Experimental Researches" (*see* page 151).

P. Gassiot, Esq. . .	£20	To be annual for 5 years.	Sir John P. Boileau, Bart.	£20
P. Gassiot, Esq. jun. .	20		Professor Tyndall . .	20
ofessor Faraday . .	20		The Rev. John Barlow .	10

The Special Thanks of the Members were returned to **Isaac THIAN Bell** and Brothers, of Newcastle-upon-Tyne, for their able gift of Seven Pounds of Sodium.

he **Presents** received since the last Meeting were laid on the table, the thanks of the Members returned for the same: viz.—

OM
Trustees of the British Museum—Himyaritic Inscriptions from Southern Arabia. Folio. 1863.
enician Inscriptions from Carthage. Folio. 1863.
rnor-General of India—Memoirs of Geological Survey of India:—
leontologica Indica. No. II. 4, 5. 4to. 1863.
h Government—Documents Inédits de l'Histoire de France:—
tulaire de l'Abbaye de Redon en Bretagne. Ed. A. De Courson. 4to. 1863.
gotiations, Lettres et Pièces relatives à la Conférence de Loudun, 1616. Ed. M. Bouchitté. 4to. 1862.

Accademia dei Georgifili di Firenze—Rendiconti della Adunanze. Triennio V. Anno 1. Dispense 1-6. 8vo. 1863.

Actuaries, Institute of—Assurance Magazine, No. 52. 8vo. 1863.

Adde, M. Jules (*the Author*)—Quadrature du Cercle. (L 14) 8vo. 1863.

Agricultural Society of England, Royal—Journal. Vol. XXIV. Part 2. 8vo. 1863.

American Academy of Arts and Sciences—Memoirs. New Series. Vol. VIII. Part 2. 4to. 1863.

Proceedings. Vol. V. Nos. 49–58. Vol. VI. Nos. 1–10. 8vo. 1862.

Antiquaries, Society of—Archæologia. Vol. XXXIX. Part 1. 4to. 1863.

Asiatic Society of Bengal—Journal, No. 290, and Supplement. 8vo. 1863.

Astronomical Society, Royal—Monthly Notices, Nos. 8, 9. 8vo. 1863.

Bache, Dr. A.—Report of the United States Coast Survey, 1859-60. 2 vols. 4to.

Banting, William, Esq. (*the Author*)—Letter on Corpulence. (K 90). 8vo. 1863.

Basel Natural History Society—Verhandlungen. Theil III. Heft 4. 8vo. 1863.

Bavarian Academy, Royal—Abhandlungen. Band IX. Abth. 3. 4to. 1863.

Sitzungsberichte, 1863. Band I. Heft 3. 8vo.

Annalen der kön. Sternwarte bei München. Band XI. 8vo. 1862.

Bombay Geographical Society—Transactions. Vol. XVI. 8vo. 1863.

Boston Society of Natural History, U.S.—Journal. Vol. VII. Nos. 2, 3. 8vo. 1861–2.

Proceedings. Vol. IX. Nos. 4–11. 1862–3.

Constitution and By-Laws. 8vo. 1855.

Briscoe, John Ivatt, Esq. M.P. M.R.I.—W. A. Broomfield: Flora Vectensis [of the Isle of Wight]. With Map. Ed. Sir W. J. Hooker and T. B. Salter. 8vo. 1856.

British Association for the Advancement of Science—Report of the Thirty-second Meeting, held at Cambridge in October, 1862. 8vo. 1863.

British Meteorological Society—Proceedings, Vol. I. No. 8. 8vo. 1863.

Institutes. 1861. 8vo. 1863.

Brown, Robert, Esq. (*the Author*)—Elements of Musical Science. 4to. 1860.

Burdett-Coutts, Miss, M.R.I.—The Lignite Formation of Bovey Tracey, Devonshire. By W. Pengelly and O. Heer. (Phil. Trans. Vol. II. 1862.) 4to. 1863.

Chemical Society—Journal, Nos. 8, 9, 10. 8vo. 1863.

Colburn, Zerah, Esq. (*the Author*)—Steam-Boiler Explosions. (K 90) 8vo. 1863.

Constant, Roch (*the Author*)—Mémoire sur l'Histoire de la Création au Sein de notre Sphère Universelle. (K 90) Paris. 1863.

Editors—Artizan for July to October, 1863. 4to.

Athenæum for July to October, 1863. 4to.

Chemical News for July to October, 1863. 4to.

Engineer for July to October, 1863. fol.

Horological Journal, Nos. 60, 61, 62. 8vo. 1863.

Journal of Gas-Lighting for July to October, 1863. 4to.

Mechanics' Magazine for July to October, 1863. 8vo.

Medical Circular for July to October, 1863. 8vo.

Practical Mechanics' Journal for July to October, 1863. 4to.

St. James's Medley, Nos. 35, 36. 8vo. 1863.

Technologist for July to October, 1863. 8vo.

Franklin Institute of Pennsylvania—Journal, Nos. 450-453. 8vo 1863.

Geographical Society, Royal—Proceedings, Vol. VII. Nos. 3, 4, 5. 8vo. 1863.

Geological Institute, Vienna—Jahrbuch, 1863. No. 3. 8vo.

Geological Society—Quarterly Journal, No. 75. 8vo. 1863.

Gulliver, G. Esq. (*the Author*)—Hunterian Oration, 1863. (K 90) 8vo.

Hawkins, James, Esq. (*the Author*)—The Physical, Moral, and Intellectual Constitution of the Deaf and Dumb. 12mo. 1863.

Horticultural Society, Royal—Proceedings, 1863. No. 7. 8vo.

James, Sir Henry, C.E. Director of the Ordnance Survey—Extension of the Triangulation of the Ordnance Survey into France and Belgium. 4to. 1863.

London, Corporation of—Third Supplement to Library Catalogue. 8vo. 1863.

ck, *John, Esq. F.R.S. M.R.I.* (*the Author*)—A Visit to the Ancient Shell Mounds of Scotland. (From Nat. Hist. Rev. 1863.)

the Development of Chloëon (Ephemera) Dimidiatum. Part 1. (From Trans. Linn. Soc. Vol. XXIV.) 4to. 1863.

anical Engineers' Institution, Birmingham—Proceedings, November, 1862; January, 1863. 8vo.

cal and Chirurgical Society, Royal—Proceedings, Vol. IV. No. 4. 8vo. 1863. ditions to Library. No. 6. 8vo. 1863.

e, E. Vansittart, Esq. M.R.I. (*the Author*)—Analogy of Thought and Nature nvestigated. 16to. 1863.

on, Messrs.—London Journal (New Series) for July to October, 1863. 8vo.

Scotian Institute of Natural Science—Transactions. Vol. I. Part 1. 8vo. 1863.

mann, A. Esq. (*the Editor*)—Mittheilungen aus dem Gesammtgebiete der Geographie. Nos. 6, 7, 8, 9. 4to. 1863.

graphic Society—Journal, Nos. 135-138. 8vo. 1863.

au, M. Hon. M. M.R.I.—Une Récréation Arithmétique, &c. 8vo. 1863.

l Observatory, Greenwich (*through the Royal Society*)—Astronomical, Meteorological, and Magnetical Observations in 1861. 4to. 1863.

l Society of London—Proceedings, Nos. 56, 57. 8vo. 1863. ilosophical Transactions, 1862: Vol. CLII. Part 2. 1863: Vol. CLIII. Part 1. 4to.

man, Professors (*the Editors*)—American Journal of Science, Nos. 106, 107. 8vo. 1863.

sonian Institution, Washington, U.S.—Annual Report for 1861. 8vo. 1862.

tical Society—Journal, Vol. XXVI. Part 3. 8vo. 1863.

all, Professor, F.R.S. M.R.I.—Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen de Haarlem. Twede Verzameling. XIV. Deel. 2e Stuck; XV. Deel; XVI. Deel. 4to. 1861-62.

d Service Institution, Royal—Journal, No. 26. 8vo. 1863.

ins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Marz s Juni, 1863. 4to.

, *Edward, Esq.*—A Piece of Magnesium Ore, a very pure arbonate, from the island of Eubœa.

GENERAL MONTHLY MEETING.

Monday, December 7, 1863.

lliam Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

John Frederick Bateman, Esq. F.R.S.
John Berners, Esq.
John Charles Bucknill, M.D. F.R.C.P.
William Douglas, Esq.
Lady Everest.
J. Warrington Haward, Esq. M.R.C.S.
Robert James Lee, Esq. B.A. Cantab.
Edward Henry Moscrop, Esq.
Lieut.-Col. Archibald Park.
William Stones, Esq.

elected Members of the Royal Institution.

Ernest Hart, Esq.
T. Harrington Tuke, Esq.

were *admitted* Members of the Royal Institution.

The Secretary announced the following additions to "the Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

H.R.H. The Count of Paris .	£50	
Miss Harriet Moore . . .	50	(The same promised for next year.)
Miss Julia Moore . . .	5	
William Pole, Esq. Treas. R.I.	20	
Dr. J. H Gladstone, F.R.S. .	100	
George Dodd, Esq. . . .	20	
T. Harrington Tuke, Esq. .	10 10*s.*	

The following Resolution was passed unanimously :—

"RESOLVED, That considering the relation of science to mankind, and the progress of research and discovery in the Royal Institution during a long series of years, it is in the opinion of this Meeting a fit, important, and highly worthy object of the Members of the body to appropriate Funds for the development of Original Research in their Laboratories under their present Professors."

Read the following Proposed Alterations, or Suspensions, of the Bye-Laws, to be considered at the General Monthly Meeting, February 1, 1864 :—

"We, the Undersigned, propose that the following Alterations, or Suspensions, be made in the Bye-Laws of the Royal Institution :—

"1. That the Bye-Law, Chap. XI. Art. 2, be suspended for the years 1864, 1865, and 1866.

"2. That the Bye-Law, Chap. XXI. Art. 4, be suspended for the years 1864, 1865, and 1866.

"3. That so much of the Bye-Law, Chap. XXI. Art. 6, as provides that the Expenses of the Laboratory be not permitted to exceed the sum of 400*l.* per annum, be suspended for the years 1864, 1865, and 1866.

4. "That the Bye-Law, Chap. XXI. Art. 7, be suspended for the years 1864, 1865, and 1866.

WILLIAM POLE.
J. BARLOW.
GEORGE DODD.
GEORGE BUSK.
GEORGE EVEREST.
M. FARADAY.
J. P. GASSIOT.
PHILIP J. YORKE.
HENRY HOLLAND.
H. BENCE JONES.
W. F. POLLOCK.

JOHN C. BURGOYNE.
J. H. GLADSTONE.
T. HARRINGTON TUKE.
GEORGE STODART.
THOMAS DAVIDSON.
J. R. ANDREWS.
ANDREW PRITCHARD.
D. MACLOUGHLIN.
JOHN BELL SEDGWICK.
HENRY STRACHEY."

The Managers reported the engagement of Mr. William Fletcher Barrett and Mr. John Broughton, as skilled Assistants in the Laboratories of the Royal Institution.

LECTURE ARRANGEMENTS for the ensuing Season :—

Christmas Lectures, 1863. (*Adapted to a Juvenile Auditory.*)

Prof. TYNDALL, F.R.S.—Six Lectures, 'On Electricity at Rest and Electricity in Motion.'

Before Easter, 1864.

Prof. TYNDALL, F.R.S.—Twelve Lectures, 'On Experimental Optics.'

JOHN LUBBOCK, Esq. F.R.S.—Three Lectures, 'On the Antiquity of Man.'

Prof. FRANKLAND, F.R.S.—Six Lectures, 'On the Metallic Elements.'

Prof. MARSHALL, F.R.S.—Six Lectures, 'On the Chemical Phenomena of Animal Life.'

After Easter.

Prof. HELMHOLTZ, F.R.S. — Six Lectures, 'On the Natural Law of Conservation of Energy.'

Prof. J. BLACKIE—Two Lectures on Homer.

Prof. FRANKLAND, F.R.S.—Six Lectures, 'On the Metallic Elements.'

Prof. MARSHALL, F.R.S.—Six Lectures, 'On the Morphological Phenomena of Animal Life.'

JOHN HULLAH, Esq.—Six Lectures, 'On the Third Period of Musical History : from cir. 1600 to cir. 1750.'

ALEXANDER HERSCHEL, Esq.—Four Lectures, 'On Falling Stars and Meteorolites.'

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same : viz.—

FROM

Lords of the Admiralty, through J. R. Hinde, Esq.—The Nautical Almanac for 1865, 1866, 1867. 8vo 1862-3.

Actuaries, Institute of—Assurance Magazine, No. 53. 8vo. 1863.

Astronomical Society, Royal—Memoirs. Vol. XXXI. 4to. 1863.

British Architects, Institute of—Sessional Papers. Part I. Nos. 1, 2. 4to. 1863.

Chemical Society—Journal, No. 11. 8vo. 1863.

College of Surgeons of England, Royal—Catalogue of the Pathological Specimens in their Museum. Supplement I. 4to. 1863.

Cole, Henry, C.B., Secretary of the Science and Art Department of the Committee of Council on Education—Catalogue of the Special Exhibition of Works of Art of the Mediæval and Renaissance and more Recent Periods, on Loan at the South Kensington Museum in 1862. 8vo. 1863.

Editors—Artizan for November, 1863. 4to.
Athenæum for November, 1863. 4to.
Chemical News for November, 1863.
Engineer for November, 1863. fol.
Horological Journal, Nos. 63, 64. 8vo. 1863.
Journal of Gas-Lighting for November, 1863. 4to.
Mechanics' Magazine for November, 1863. 8vo.
Medical Circular for November, 1863. 8vo.
Practical Mechanics' Journal for November, 1863. 4to.
Technologist for November, 1863. 8vo.
Electrician for November, 1863. 4to.

Faraday, Professor, D.C.L., F.R.S. Akademie der Wissenschaften, Wien:—Math. Nat. Classe: Denkschriften. Band XXI. 4to. 1863.
Sitzungsberichte: I^{e} Abth. Band XLV. 3, 4, 5. Band XLVI. Band XLVII. 1, 2, 3. 8vo. 1862-3. II. Abth. Band XLVI. XLVII. 8vo. 1862-3.
J. R. Lorenz—Physikalische Verhältnisse und Vertheilung der Organismen im Quarnerischen Golfe. 8vo. 1863.
Franklin Institute of Pennsylvania—Journal, No. 454. 8vo. 1862.
Geographical Society, Royal—Proceedings, Vol. VII. Nos. 3, 4, 5. 8vo. 1863.
Geological Society—Quarterly Journal, No. 76. 8vo. 1863.
Hekekyan Bey, C.E. (the Author)—Treatise on the Chronology of Siriadic Monuments. 8vo. 1863.
Herschel, Sir John F. Bart. F.R.S. (the Author)—An Essay, entitled The Yard, the Pendulum, and the Metre, considered in reference to the Choice of a Standard of Length. (K 90) 8vo. 1863.
Horticultural Society, Royal—Proceedings, 1863. No. 8. 8vo.
Linnean Society—Proceedings, No. 27. 8vo. 1863.
Medical and Chirurgical Society of London, Royal—Medico-Chirurgical Transactions. Vol. XLVI. 8vo. 1863.
Newton, Messrs.—London Journal (New Series) for November, 1863. 8vo.
Petermann, A. Esq. (the Editor)—Mittheilungen aus dem Gesammtgebiete der Geographie. No. 10. 4to. 1863.
Photographic Society.—Journal, No. 139. 8vo. 1863.
Reddie, James, Esq. (the Author)—Victoria Toto Cœlo; or, Modern Astronomy recast. (K 90) 8vo. 1863.
Royal Society of London—Proceedings, No. 58. 8vo. 1863.
Sächsische Gesellschaft der Wissenschaften, Kön.—Abhandlungen. Vol. IX. No. 4. Vol. X. No. 4. 8vo. 1863. Berichte. 1863. 8vo.
Savory Wm. S., Esq. F.R.S. (the Author)—On Life and Death: Four Lectures delivered at the Royal Institution of Great Britain. 16to. 1863.
United Service Institution, Royal—Journal, No 27. 8vo. 1863.
Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Juli und Aug. 1863. 4to.
Tyndall, Professor, F.R.S.—Four Specimens of Rock Salt.

1864.

WEEKLY EVENING MEETING,

Friday, January 22, 1864.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

W. R. GROVE, Esq. Q.C. F.R.S. M.R.I.

On Boiling Water.

A PAPER by M. Donny ('Mémoires de l'Académie Royale de Bruxelles,' 1843) makes known the fact that in proportion as water is deprived of air, the character of its ebullition changes, becoming more and more abrupt, and boiling like sulphuric acid with *soubresauts*, and that between each burst of vapour the water reaches a temperature above its boiling point. To effect this, it is necessary that the water be boiled in a tube with a narrow orifice, through which the vapour issues; if it be boiled in an open vessel, it continually re-absorbs air and boils in the ordinary way.

In my experiments on the decomposition of water by heat, I found that with the oxy-hydrogen gas given off from ignited platinum plunged into water, there was always a greater or less quantity of nitrogen mixed; this I could never entirely get rid of, and I was thus led into a more careful examination of the phenomenon of boiling water, and set before myself this problem—what will be the effect of heat on water perfectly deprived of air or gas?

Two copper wires were placed parallel to each other through the neck of a Florence flask, so as nearly to touch the bottom, joining the lower ends of these was a fine platinum wire, about 1½ inch long, and bent horizontally into a curve. Distilled water, which had been well boiled and cooled under the receiver of an air-pump, was poured into this flask so as to fill about one-fourth of its capacity. It was then placed under the receiver of an air-pump, and one of the copper wires brought in contact with a metallic plate covering the receiver, the other bent backwards over the neck of the flask, and its end made to rest on the pump plate. By this means, when the terminal wires from a voltaic battery were made to touch, the one the upper and the other the lower plate, the platinum wire would be heated, and the boiling continued indefinitely in the vacuum of a very excellent air-pump. The effect was very curious; the water did not boil in the ordinary manner, but at intervals a burst of vapour took place, dashing the water against the sides of the flask, some escaping into the receiver. (There was a projection at the central orifice of the pump-plate to prevent this overflow getting into the exhausting tube.)

After each sudden burst of vapour, the water became perfectly tranquil, without a symptom of ebullition until the next burst took place. These sudden bursts occurred at measured intervals, so nearly equal in time, that, had it not been for the escape from the flask, at each burst, of a certain portion of water, the apparatus might have served as a timepiece.

This experiment, though instructive, did not definitely answer the question I had proposed, as I could not of course ascertain whether there was some minute residuum of gas which would form the nucleus for each ebullition; and I proceeded with others. A tube of glass, 5 feet long and $\frac{4}{10}$ths inch internal diameter, was bent into a V shape; into one end a loop of platinum wire was hermetically sealed with great care, and the portion of it in the interior of the tube was platinized. When the tube had been well washed, distilled water, which had been purged of air as before, was poured into it to the depth of 8 inches, and the rest of the tube filled with olive oil; when the V was inverted, the open end of the tube was placed in a vessel of olive oil, so that there would be 8 inches of water resting on the platinum wire, separated from the external air by a column of 4 feet 4 inches of oil. The projecting extremities of the platinum wire were now connected with the terminals of a voltaic battery and the water heated; some air was freed and ascended to the level of the tube—this was made to escape by carefully inverting the tube so as not to let the oil mix with the water—and the experiment continued. After a certain time the boiling assumed a uniform character, not by such sudden bursts as in the Florence flask experiment, but with larger and more distinct bursts of ebullition than in its first boiling.

The object of platinizing the wire was to present more points for the ebullition, and to prevent *soubresauts* as much as possible.

The experiment was continued for many hours, and in some repetitions of it for days. After the boiling had assumed a uniform character, the progress of the vapour was carefully watched, and as each burst of vapour condensed in the oil, which was kept cool, it left a minute bead of gas, which ascended through the oil to the bend of the tube: a bubble was formed here which did not seem at all absorbed by the oil. This was analyzed by a eudiometer, which I will presently describe, and proved to be nitrogen. The beads of gas, when viewed through a lens and micrometer scale at the same height in the tube, appeared as nearly as may be of the same size. No bubble of vapour was condensed completely, or without leaving this residual bubble. The experiment was frequently repeated, and continued until the water was so nearly boiled away, that the oil, when disturbed by the boiling, nearly touched the platinum wire; here it was necessarily stopped.

To avoid any question about the boiling being by electrical means, similar experiments were made with a tube, without a platinum wire, closed at its extremity, and the boiling was produced by a spirit-lamp. The effects were the same, but the experiment was more difficult and imperfect, as the bursts of vapour were more sudden, and the duration of the intervals more irregular.

The beads of gas were extremely minute, just visible to the naked eye, but were made visible to the audience by means of the electric lamp.

In these experiments there was no pure boiling of water, *i. e.* no rupture of cohesion of the molecules of water itself, but the water was boiled, to use M. Donny's expression, by evaporation against a surface of gas.

It is hardly conceivable that air could penetrate through such a column of oil, the more so as the oil did not perceptibly absorb the nitrogen freed by the boiling water and resting in the bend of the tube; but to meet this conjectural difficulty, the following experiment was made. A tube, 1 foot long and $\frac{3}{10}$ths inch internal diameter, bent into a slight angle, had a bulb of $\frac{3}{4}$-inch diameter blown on it at the angle; this angle was about 3 inches from one end and 9 from the other: a loop of platinum wire was sealed into the shorter leg, and the whole tube and bulb filled with and immersed into mercury: water, distilled and purged of air as before, was allowed to fill the short leg, and by carefully adjusting the inclination, the water could be boiled so as to allow bubbles to ascend into the bulb and displace the mercury. The effect was the same as with the oil experiment, no ebullition without leaving a bead of gas; the gas collected in the bulb, and was cut off by what may be termed a valve of mercury, from the boiling water, then allowed to escape, and so on; the experiment was continued for many days, and the bubbles analyzed from time to time; they proved, as before, to be nitrogen; and, as before, continued indefinitely.

A similar experiment was made without the platinum wire, and though, from the greater difficulties, the experiment was not so satisfactory, the result was the same.

As the mercury of the common barometer will keep air out of its vacuum for years, if not for centuries, there could be no absorption here from the external atmosphere, and I think I am fairly entitled to conclude from the above experiments—which I believe went far beyond any that have been recorded—that no one has yet seen the phenomenon of pure water boiling,—*i. e.* of the disruption of the liquid particles of the oxy-hydrogen compound so as to produce vapour which will, when condensed, become water, leaving no permanent gas. Possibly, in my experiment of the decomposition of water by ignited platinum, it may be that the sudden application of intense heat, and in some quantity, so forces asunder the molecules that, not having sufficient nitrogen dissolved to supply them with a nucleus for evaporation, the integral molecules are severed, and decomposition takes place. If this be so, and it seems to me by no means a far-fetched theory, there is probably no such thing as boiling, properly so called, and the effect of heat on liquids in which there is no dissolved gas may be to decompose them.

Considerations such as these led me to try the effect of boiling on an elementary liquid, and bromine occurred as the most promising one to work upon; as bromine could not be boiled in contact with water, oil, or mercury, the following plan was ultimately devised. A tube, 4 feet long and $\frac{4}{10}$ths inch diameter, had a platinum loop sealed into one closed extremity: bromine was poured into the tube to the height of 4 inches; the open end of the tube was then drawn out to a fine point by the blow-pipe, leaving a small orifice; the bromine was then heated by a spirit-lamp; and when all the air was expelled, and a jet of bromine vapour issued from the point of the tube, it was sealed by the blow-pipe. There was then, when the bromine vapour had condensed, a vacuum in the tube above the bromine. The platinum loop was now heated by a voltaic battery, and the bromine boiled: this was continued for some time, care being taken that the boiling should not be too violent. At the end of a certain period—from half-an-hour to an hour—the platinum loop gave way, being corroded by the bromine; the quantity of this had slightly decreased. On breaking off, under water, the point of the tube, the water mounted and showed a notable quantity of permanent gas, which on analysis proved to be pure oxygen. As much as a quarter of a cubic inch was collected at one experiment. The platinum wire, which had severed at the middle, was covered with a slight black crust, which, suspecting to be carbon, I ignited by a voltaic spark in oxygen in a small tube over lime-water; it seemed to give a slight opalescence to the liquid, but the quantity was so small that the experiment was not to be relied on. No definite change was perceptible in the bromine; it seemed to be a little darker in colour and had a few black specks floating in it, which I judged to be minute portions of the same crust which had formed on the platinum wire, and which had become detached.

The experiment was repeated with chloride of iodine and with the same result, except that the quantity of oxygen was greater: I collected as much as half a cubic inch in some experiments, from an equal quantity of chloride of iodine, the platinum wire, however, was more quickly acted on than with the bromine, and the glass of the tube around it to some extent.

Melted phosphorus was exposed to the heat of the voltaic disruptive discharge by taking this between platinum points in a tube of phosphorus, similarly to an experiment of Davy's, but with better means of experimenting; a considerable quantity of phosphuretted hydrogen was given off, amounting in several experiments to more than a cubic inch.

A similar experiment was made with melted sulphur, and sulphuretted hydrogen was given off, but not in such quantities as the phosphuretted hydrogen. I tried in vain to carry on these experiments beyond a certain point; the substance became pasty, mixed with platinum from the arc, and from the difficulty of working with the same freedom as when they were fresh, the glass tubes were always broken after a certain time. Had I time for working on the subject now, I should use the discharge from the Ruhmkorf coil, which had not been invented at the period of these experiments. At a subsequent period, when this discharge was taken in the vacuous receiver of an air-pump from a metallic point to a metallic capsule containing phosphorus, a considerable yellow deposit lined the receiver, which, on testing, turned out to be allotropic phosphorus. No gas is, however, given off. I had an air-pump (described, 'Phil. Trans.,' 1852, p. 101) which enabled me to detect very small quantities of gas, but I could get none. It was in making these experiments that I first detected the striæ in the electric discharge, which have since become a subject of such interesting observations, which are seen, perhaps, more beautifully in this phosphorus vapour than in any other medium, and which cease, or become very feeble, where the allotropic phosphorus is not produced.

I tried also phosphorus highly heated by a burning-glass in an atmosphere of nitrogen, but could eliminate no perceptible quantity of gas, though the phosphorus was changed into the allotropic form.

It is not difficult to understand why gas is not perceptibly eliminated in the last two experiments; the effect is probably similar to that described in my paper on the "Decomposition of Water by Heat," where, when the arc or electric spark is taken in aqueous vapour, a minute ubble of oxyhydrogen gas is freed and disseminated through the apour, recombination being probably prevented by this dilution ; but, owever long the experiment may be continued, no increased quantity f the gas is obtained, all beyond this minute quantity being recomined. If, however, the bubble of gas be collected, by allowing the apour to cool, and then expelled, a fresh portion is decomposed, and o on.

So with the phosphorus in the experiments in the air-pump and ith the burning-glass; if any gas is liberated it is probably immeiately recombined with the phosphorus; possibly a minute residuum ight escape recombination, but the circumstances of the experiment id not admit of this being collected, as the gas was with the aqueous apour.

When, on the other hand, the gas freed is immediately cut off from he source of heat, as when the spark is taken in liquids, an indefinite uantity can be obtained.

Decomposition and the elimination of gas may thus take place by he application of intense heat to a point in a liquid, or also in gas or apours; but, in the latter case, it is more likely to be masked by the uantity of gas or vapour through which it is disseminated.

I believe there are very few gases in which some alteration does ot take place by the application of the intense heat of the voltaic arc r electric spark. If the arc be taken between platinum points in dry xygen-gas over mercury, the gas diminishes indefinitely, until the ercury rises, and by reaching the point where the arc takes place, uts an end to the experiment. I have caused as much as a cubic inch f oxygen to disappear by this means. I at one time thought this was ue to the oxidation of the platinum; but the high heat renders this nprobable, and the deposit formed on the interior of the glass tube in hich the experiment is made has all the properties of platinum black; o if the spark from a Ruhmkorf coil be taken in the vapour of water or several days, a portion of gas is freed which is pure hydrogen, the xygen freed being probably changed into ozone, and dissolved by the ater in this case, while in the former it combined with the mercury.

I have alluded to the eudiometer by which I analyzed the gases btained in these experiments; it was formed simply of a tube of glass, requently not above 2½ millimetres in diameter, with a loop of wire ermetically sealed into one end, the other having an open bell-mouth. By a platinum wire a small bubble of the gas to be examined could be ot up through water or mercury into the closed end of the tube, and y the addition of a bubble of oxygen or hydrogen gas, a very accurate nalysis of very minute quantities of gas could be made: I have analyzed by this means quantities no larger than a partridge-shot.

I need hardly allude to results on the compound liquids, such as ils and hydrocarbons, as the fact that permanent gas is given off in oiling such liquids would not be unexpected; but the above experiments seem to show that boiling is by no means necessarily the henomenon that has generally been supposed, *viz.* a separation of cohesion in the molecules of a liquid from distension by heat. I believe, from the close investigation I made into the subject, that (except with the metals, on which there is no evidence) no one has seen the phenomenon of pure boiling without permanent gas being freed, and that what is ordinarily termed boiling arises from the extrication of a bubble of permanent gas either by chemical decomposition of the liquid, or by the separation of some gas associated in minute quantity with the liquid, and from which human means have hitherto failed to purge it; this bubble once extricated, the vapour of the liquid expands it, or, to use the appropriate phrase of M. Donny, the liquid evaporates against the surface of the gas.

My experiments are, in a certain sense, the complement of his. He showed that the temperature of the boiling point was raised in some proportion as water was deprived of air, and that under such circumstances the boiling took place by *soubresauts*. I have, I trust, shown that when the vapour liberated by boiling is allowed to condense, it does not altogether collapse into a liquid, but leaves a residual bubble of permanent gas, and that at a certain point this evolution becomes uniform.

Boiling, then, is not the result of merely raising a liquid to a given temperature, it is something much more complex.

One might suppose that with a compound liquid the initial bubble by which evaporation is enabled to take place might, if all foreign gas were or could be extracted, be formed by decomposition of the liquid: but this could not be the case with an elementary liquid; whence the oxygen from bromine or the hydrogen from phosphorus and sulphur? As with the nitrogen in water, it may be that a minute portion of oxygen, hydrogen, or of water is inseparable from these substances, and that if boiled away to absolute dryness, a minute portion of gas would be left for each ebullition.

With water there seems a point at which the temperature of ebullition and the quantity of nitrogen yielded become uniform, though the latter is excessively minute.

The circumstances of the experiments with bromine, phosphorus, and sulphur, did not permit me to push the experiment so far as was done with water, but as far as it went the result was similar.

When an intense heat, such as that from the electric spark or voltaic arc, is applied to permanent gas, there are, in the greater number of cases, signs either of chemical decomposition or of molecular change; thus compound gases, such as hydrocarbons, ammonia, the oxides of nitrogen, and many others are decomposed. Phosphorus in vapour is changed to allotropic phosphorus, oxygen to ozone, which, according to present experience, may be viewed as allotropic oxygen. There may be many cases where, as with aqueous vapour, a small portion only is decomposed, and this may be so masked by the volume of undecomposed gas as to escape detection; if, for instance, the vapour of water were incondensable, the fact that a portion of it is decomposed by the electric spark or ignited platinum would not have been observed.

All these facts show that the effect of intense heat applied to liquids and gases is much less simple, and presents greater interest to the chemist than has generally been supposed. In far the greater number of cases, possibly in all, it is not mere expansion into vapour which is produced by intense heat, but there is a chemical or molecular change. Had circumstances permitted I should have carried these experiments further, and endeavoured to find an *experimentum crucis* on the subject. There are difficulties with such substances as bromine, phosphorus, &c., arising from their action on the substances used to contain and heat them, which are not easy to vanquish, and those who may feel inclined to repeat my experiments will find these difficulties greater than they appear in narration; but I do not think they are insuperable, and hope that, in the hands of those who are fortunate enough to have time at their disposal, they may be overcome.

To completely isolate a substance from the surrounding air and yet be able to experiment on it, is far more difficult than is generally supposed. The air-pump is but a rude mode for such experiments as are here detailed.

Caoutchouc joints are out of the question; even platinum wires carefully sealed into glass, though, as far as I have been able to observe, forming a joint which will not allow gas to pass, yet it is one through which liquids will effect a passage, at all events when the wires are repeatedly heated.

In some experiments with the ignited platinum wire hermetically sealed into a tube of glass, the end of the tube containing the platinum wire was placed in a larger tube of oil, to lessen the risk of cracking the glass. After some days' experimenting, though the sealing remained perfect, a slight portion of carbon was found in the interior liquid. This does not affect the results of my experiments, as I repeated them with glass tubes closed at the end and without platinum wires, and also without the oil-bath; but it shows how difficult it is to exclude sources of error. When water has been deprived of air to the greatest practicable extent it becomes very avid for air. The following experiment is an instance of this: A single pair of the gas-battery, the liquid in which was cut off from the external air by a greased glass stopper, having one tube filled with water, the other with hydrogen, the platinized platinum plates in each of these tubes were connected with a galvanometer, and a deflection took place from the reaction of the hydrogen on the air dissolved in the water. After a time the deflection abated, and the needle returned to zero, all the oxygen of the air having become combined with the hydrogen. If now the stopper were taken out, a deflection of the galvanometric needle immediately took place, showing that the air rapidly enters the water as water would a sponge. Absolute chemical purity in the ingredients is a matter, for refined experiments, almost unattainable; the more delicate the test, the more some minute residual product is detected; it would seem (to put the proposition in a somewhat exaggerated form) that in nature everything is to be found in anything if we carefully look for it.

I have indicated the above sources of error to show the close pursuit that is necessary when looking for these minute residual phenomena. Enough has, I trust, been shown in the above experiments to lead to the conclusion that, hitherto, simple boiling, in the sense of a liquid being expanded by heat into its vapour without being decomposed or having permanent gas eliminated from it, is a thing unknown. Whether such boiling *can* take place may be regarded as an open question, though I incline to think it cannot; that if water, for instance, could be absolutely deprived of nitrogen, it would not boil until some portion of it was decomposed; that the physical severance of the molecules by heat is also a chemical severance. If there be anything in this theoretic view, there is great promise of important results on elementary liquids, if the difficulties to which I have alluded can be got over.

The constant appearance of nitrogen in water, when boiled off out of contact with the air almost to the last drop, is a matter well worthy of investigation. I will not speculate on what possible chemical connection there may be between air and water; the preponderance of these two substances on the surface of our planet, and the probability that nitrogen is not the inert diluent in respiration that is generally supposed, might give rise to not irrational conjectures on some unknown bond between air and water. But it would be rash to announce any theory on such a subject; better to test any guess one may make, by experiment, than to mislead by theory without sufficient data, or to lessen the value of facts by connecting them with erroneous hypotheses.

[W. R. G.]

WEEKLY EVENING MEETING,

Friday, January 29, 1864.

Colonel Philip James Yorke, F.R.S. in the Chair.

Edward Frankland, Esq. F.R.S.

PROFESSOR OF CHEMISTRY, ROYAL INSTITUTION.

On the Glacial Epoch.

Amongst the circumstances that have profoundly influenced the present physical condition of our earth, the action of ancient glaciers upon a scale of almost inconceivable magnitude has been gradually but irresistibly forcing itself upon the notice of philosophers since their attention was first called to it by Venetz and Esmark. There are few elevated regions in any quarter of the globe which do not exhibit indubitable evidence of the characteristic grinding and polishing action of ice-masses, although at present, perhaps, they are scarcely streaked

the snows of winter. In our own country the researches of Buck-
l, and especially of Ramsay, have clearly shown that the Highlands
Scotland, the mountains of Wales and Cumberland, and the lime-
se crags of Yorkshire, abound in these *roches moutonnés*, which
re no doubt that the valleys of those mountain ranges were once
d with glaciers of dimensions unsurpassed, if even equalled, by
se which at the present day stream down the sides of their gigantic
ss rivals. Nor was this perpetual ice of a former age confined to
lities where no such phenomenon is now seen, but numerous obser-
ions have established that the glaciers of the present age, existing
Switzerland, Norway, and elsewhere, are but the nearly dried-up
amlets of ancient ice rivers of enormous size. These glaciers
e eroded the Alpine valleys, of which they once held possession,
e carved out the lochs and kyles of Scotland, as well as the
nder fjords of Norway, and have contributed in a most essential
nner to the present aspect of our mountain scenery. Ramsay
l Tyndall have recently called attention to this action of ancient
ciers, and have contended with considerable plausibility, the
mer that the lake basins, the latter that the valleys of the
ps, have been thus, in great part, scooped out. In no part of the
rld, perhaps, can the phenomena of the glacial epoch be more
vantageously studied than in Norway, where the ice-scarred coasts
d fjords are still fully exposed to the eye of the observer, side
' side with the ocean, which furnished the crystalline material
at formerly covered them. Two thousand miles of coast, from
hristiania to the North Cape, afford almost uninterrupted evi-
nce of the vast ice operations which, during the epoch in question,
oulded nearly every feature of this remarkable country. Starting
m Christiania, the traveller cannot fail to remark the peculiar
pearance of the gneiss and granite rocks composing the coast, as
ll as the innumerable islands which, forming a great natural break-
ter, protect the shore from the heavy seas rolling in from the
lantic. These rocks, here rarely rising to the height of 800 or
0 feet, present nothing of that sharp and rugged outline which
erally characterizes such formations. On the contrary, they are
oothed even to their summits, all their angles worn off, and every
ce of boldness and asperity effaced. To the casual and uninstructed
erver the action of the sea suggests itself as a sufficient cause of
se appearances; but it does not require much scrutiny to be con-
ced that the ocean waves have had little to do with this smooth-
and polishing of the coast, since it is the surfaces sloping towards
land that are most acted upon, whilst in some places, where the
t descends precipitously towards the sea, and is subject to the dash
the waves, it has been protected from the abrading action, and
ents merely a weathered surface.

Rounding the promontory of the Naze and proceeding northward,
coast presents, with slight exceptions, the same general features
l the Arctic circle is approached, when the character of the scenery

rather suddenly changes. The rocky hills acquire the dignity of mountains, and tower up in rugged, sharp, and fantastic peaks, contrasting strongly with the rounded summits of the lower latitudes. But these arctic peaks owe their immunity from the abrading action of ice solely to their height; around their bases, and even high up their sides, the slow surges of the moving glacial sea have made their unmistakable marks, grinding, and even undercutting, them into most extraordinary forms, as fine instances of which may be mentioned the Seven Sisters, and Torghatten, with its singular tunnel, just south of the Arctic circle; the Horseman, standing on the circle; and the mountains of the Folden and Vestfjords, north of it; the latter having been justly described by the Rev. R. Everest, as resembling the jaws of an immense shark.*

To account for the advent and subsequent disappearance of such vast masses of ice, various hypotheses have been propounded. It has been suggested that the temperature of space is not uniform, and that our solar system, in performing its proper motion among the stars, sometimes passes through regions of comparatively low temperature: according to this hypothesis, the glacial epoch occurred during the passage of our system through such a cold portion of space. Some have imagined that the heat emitted by the sun is subject to variation, and that the glacial epoch happened during what may be termed a cold solar period. Others, again, believe that a different distribution of land and water would render the climate of certain localities colder than it is at present, and would thus sufficiently account for the phenomena of the glacial epoch. Finally, Professor Kämtz considers that at the time of the glacial period the mountains were much higher than at present—Mount Blanc 20,000 feet for instance—the secondary and tertiary formations having been since eroded from their summits.

The two last assumptions are attended with formidable geological difficulties, especially when it is considered that the phenomena of the epoch in question extended over the entire surface of the globe; they have therefore never acquired more than a very partial acceptance. With regard to the two first-named hypotheses, my colleague, Professor Tyndall, has recently shown that they are founded upon an entirely erroneous conception of the conditions necessary to the phenomena sought to be explained. The formation of glaciers is a true process of distillation, requiring heat as much as cold for its due performance. The produce of a still would be diminished, not increased, by an absolute reduction of temperature. A greater differentiation of temperature is what is required to stimulate the operation into greater activity. Professor Tyndall does not suggest any cause for such exalted differentiation during the glacial epoch; but he proves conclusively that both hypotheses, besides being totally unsupported by cosmical cts, are not only incompetent to constitute such a cause, but also sume a condition of things which would cut off the glaciers at their urce, by diminishing the evaporation upon which their existence sentially depends.

---

* The speaker was greatly indebted to his friend, B. F. Duppa, Esq., for beautiful coloured drawings of these remarkable objects, taken from the sketches of Professor James D. Forbes and Mr. Mattieu Williams.

The speaker divided the great natural glacial apparatus into three arts—*viz.* the evaporator, the condenser, and the receiver. The art performed by the ocean as the evaporator is too obvious to need escription. The two remaining portions of the apparatus, however, re generally confounded with each other. The mountains are in ality the receivers, or *icebearers*, and are only in a subordinate sense ondensers. The true condenser is the dry air of the upper region of e atmosphere, which permits of the free radiation into space of the eat from aqueous vapour.*

All the hypotheses hitherto propounded having therefore failed, the light of recent research, to account for the conditions which rought about the glacial epoch, the speaker felt less reluctance in dvancing a new theory, which had gradually elaborated itself out f the impressions he had received during a recent visit to Norway. ny such theory must take cognizance of the following points in the istory of the glacial epoch. 1st, That its effects were felt over the ntire globe. 2nd, That it occurred at a geologically recent period. rd, That it was preceded by a period of indefinite duration, in which lacial action was either altogether wanting, or was at least comaratively insignificant. 4th, That during its continuance atmospheric recipitation was much greater, and the height of the snow-line conderably less than at present. 5th, That it was followed by a period xtending to the present time, when glacial action became again insigificant.

All these conditions he believed to be the natural sequences of e gradual secular cooling of the surface of our globe. *The sole cause f the phenomena of the glacial epoch was a higher temperature of the ean than that which obtains at present.*

He then examined the grounds upon which this hypothesis is based. umerous observations of the augmentation of temperature, at inreasing depths from the surface of the earth, no longer leave room r doubt that the vast mass of materials constituting the interior of ur globe is at the present moment at a temperature far higher than at of the surface. If this be so, the conclusion is almost inevitable, at at earlier periods of the earth's history this high temperature ust, at all events at depths comparatively little removed from the rface, have been still higher, and that consequently the temperature f the surface itself must in former ages have been much more in-tained a high temperature, the snow-line floated above the summits, possibly even of the most lofty mountains; but with the reduction of oceanic temperature it gradually descended, enveloping peak after peak in a perennial mantle, until during the glacial epoch it attained its lowest depression, whence it again rose, owing to diminished evaporation, to its present position.

---

* This radiation from aqueous vapour was experimentally shown by causing a t of dry steam to pass in front of, and at a distance of two feet from, a thermoectric pile; the galvanometer connected with the latter promptly showed a large flection for heat, proving that the pile was receiving radiant heat from the ueous vapour. A jet of air heated in the same manner and projected in front of e pile produced no such effect.

The speaker considered, that, inasmuch as recent researches had rendered all previous hypotheses regarding the glacial epoch absolutely untenable, the one for which he now contended could not be said to come into antagonism with any other views. It also further commended itself by requiring the assumption of no natural convulsion or catastrophe, no vast or sudden upheavals or depressions, and no change in the thermal relations of our earth to the sun or to space. On the contrary, it insisted that the glacial epoch was normally and gradually evolved from a thermal condition of the interior of our globe, which could scarcely be said to be any longer the subject of controversy.

In conclusion, this hypothesis suggests the probability that the other bodies belonging to our solar system have either already passed through a similar epoch or are destined still to encounter it. With the exception of the polar ice of Mars we have hitherto obtained no certain glimpse into the thermal or meteorological condition of the planets: neither is the physical state of their surfaces accessible to our best telescopes. It is otherwise however with the moon, whose distance is not too great to prevent the visibility of comparatively minute details. A careful observation of the lunar surface for more than a year with a silvered-glass reflector of 7 inches aperture and of good defining power, had created in the speaker's mind an impression that our satellite had, like its primary, also passed through a glacial epoch, and that several at least of the *valleys*, *rills*, and *streaks* of the lunar surface were not improbably due to former glacial action. Notwithstanding the excellent definition of modern telescopes, it could not be expected that other than the most gigantic of the characteristic details of an ancient glacier bed would be rendered visible. Under favourable circumstances the terminal moraine of a glacier attains to enormous dimensions; and consequently, of all the marks of a glacial valley, this would be the one most likely to be first perceived. Two such terminal moraines, one of them a double one, appeared to him to be traceable upon the moon's surface. The first was situated near the termination of that remarkable streak which commences near the base of Tycho, and passing under the south-eastern wall of Bullialdus, into the ring of which it appears to cut, is gradually lost after passing crater 216 (Lubinietzky). Exactly opposite the last crater, and extending nearly across the streak in question, are two ridges forming the arcs of circles, whose centres are not coincident and whose external curvature is towards the north. Beyond the second ridge a talus slopes gradually down northwards to the general level of the lunar surface, the whole presenting an appearance reminding the observer of the concentric

moraines of the Rhone glacier. These ridges are visible for the whole period during which that portion of the moon's surface is illuminated, but it is only about the third day after the first quarter and at the corresponding phase of the waning moon (when the sun's rays, falling nearly horizontally, throw the details of this part of the surface into strong relief) that these appearances suggest the explanation now offered.

The other ridge, answering to a terminal moraine, occurs at the northern extremity of that magnificent valley which runs past the eastern edge of Rheita. This ridge is nearly semicircular, and is considerably elevated, both above the northern termination of the valley, and the general surface of the moon. It may be seen about four days after new and full moon, but the position of the observer, with regard to the lights and shadows, renders its appearance in the rays of the rising sun by far the most striking.

With regard to the probability of former glacial, or even aqueous, agency on the surface of the moon, difficulties of an apparently very formidable character present themselves. There is not only now no evidence whatever of the presence of water in any one of its three forms, at the lunar surface; but, on the contrary, all seleniographic observations tend to prove its absence. Nevertheless, the idea of former aqueous agency in the moon is by no means new. It was entertained by Gruithuisen and others. But if water at one time existed on the surface of the moon, whither has it disappeared? If we assume, in accordance with the nebular hypothesis, that the portions of matter composing respectively the earth and the moon once possessed an equally elevated temperature, it almost necessarily follows that the moon, owing to the comparative smallness of its mass, would cool much more rapidly than the earth; for whilst the volume of the moon is only about [illegible]th, its surface is nearly $\frac{1}{13}$th, that of the earth.

This cooling of the mass of the moon must, according to all analogy, have been attended with contraction, which can scarcely be conceived as occurring without the development of a cavernous structure in the interior. Much of this cavernous structure would doubtless communicate by means of fissures with the surface, and thus there would be provided an internal receptacle for the ocean, from the depths of which even the burning sun of the long lunar day would be totally unable to dislodge more than traces of aqueous vapour. A globe of wax was exhibited which had been cast under water; it was highly cellular, and the water had been forced into the hollow spaces, completely filling them. Assuming the solid mass of the moon to contract on cooling at the same rate as granite, its refrigeration through only 180° F. would create cellular space equal to nearly 14½ millions of cubic miles, which would be more than sufficient to engulf the whole of the lunar ocean, supposing it to bear the same proportion to the mass of the moon as our own ocean bears to that of the earth.

If such be the present condition of the moon, we can scarcely avoid the conclusion that a liquid ocean can only exist upon the surface of a

tained a high temperature, the snow-line floated above the summi possibly even of the most lofty mountains; but with the reduction oceanic temperature it gradually descended, enveloping peak after pe in a perennial mantle, until during the glacial epoch it attained lowest depression, whence it again rose, owing to diminished eva ration, to its present position.

The speaker considered, that, inasmuch as recent researches h rendered all previous hypotheses regarding the glacial epoch ab lutely untenable, the one for which he now contended could not said to come into antagonism with any other views. It also furt commended itself by requiring the assumption of no natural convulsi or catastrophe, no vast or sudden upheavals or depressions, and change in the thermal relations of our earth to the sun or to sp On the contrary, it insisted that the glacial epoch was normally a gradually evolved from a thermal condition of the interior of globe, which could scarcely be said to be any longer the subject controversy.

In conclusion, this hypothesis suggests the probability that other bodies belonging to our solar system have either already pa through a similar epoch or are destined still to encounter it. Wi the exception of the polar ice of Mars we have hitherto obtained certain glimpse into the thermal or meteorological condition of planets: neither is the physical state of their surfaces accessible our best telescopes. It is otherwise however with the moon, wh distance is not too great to prevent the visibility of comparativ minute details. A careful observation of the lunar surface for m than a year with a silvered-glass reflector of 7 inches aperture and good defining power, had created in the speaker's mind an impres that our satellite had, like its primary, also passed through a glac epoch, and that several at least of the *valleys*, *rills*, and *streaks* of lunar surface were not improbably due to former glacial action. N withstanding the excellent definition of modern telescopes, it could be expected that other than the most gigantic of the characteris details of an ancient glacier bed would be rendered visible. Un favourable circumstances the terminal moraine of a glacier attain enormous dimensions; and consequently, of all the marks of a glac valley, this would be the one most likely to be first perceived. T such terminal moraines, one of them a double one, appeared to him be traceable upon the moon's surface. The first was situated near termination of that remarkable streak which commences near the of Tycho, and passing under the south-eastern wall of Bullialdus, i the ring of which it appears to cut, is gradually lost after pa crater 216 (Lubinietzky). Exactly opposite the last crater, and exte ing nearly across the streak in question, are two ridges forming the of circles, whose centres are not coincident and whose external curvat is towards the north. Beyond the second ridge a talus slopes gradu down northwards to the general level of the lunar surface, the wh presenting an appearance reminding the observer of the concent

moraines of the Rhone glacier. These ridges are visible for the whole period during which that portion of the moon's surface is illuminated, but it is only about the third day after the first quarter and at the corresponding phase of the waning moon (when the sun's rays, falling nearly horizontally, throw the details of this part of the surface into strong relief) that these appearances suggest the explanation now offered.

The other ridge, answering to a terminal moraine, occurs at the northern extremity of that magnificent valley which runs past the eastern edge of Rheita. This ridge is nearly semicircular, and is considerably elevated, both above the northern termination of the valley, and the general surface of the moon. It may be seen about four days after new and full moon, but the position of the observer, with regard to the lights and shadows, renders its appearance in the rays of the rising sun by far the most striking.

With regard to the probability of former glacial, or even aqueous, agency on the surface of the moon, difficulties of an apparently very formidable character present themselves. There is not only now no evidence whatever of the presence of water in any one of its three forms, at the lunar surface; but, on the contrary, all seleniographic observations tend to prove its absence. Nevertheless, the idea of former aqueous agency in the moon is by no means new. It was entertained by Gruithuisen and others. But if water at one time existed on the surface of the moon, whither has it disappeared? If we assume, in accordance with the nebular hypothesis, that the portions of matter composing respectively the earth and the moon once possessed an equally elevated temperature, it almost necessarily follows that the moon, owing to the comparative smallness of its mass, would cool much more rapidly than the earth; for whilst the volume of the moon is only about $\frac{1}{49}$th, its surface is nearly $\frac{1}{13}$th, that of the earth.

This cooling of the mass of the moon must, according to all analogy, have been attended with contraction, which can scarcely be conceived as occurring without the development of a cavernous structure in the interior. Much of this cavernous structure would doubtless communicate by means of fissures with the surface, and thus there would be provided an internal receptacle for the ocean, from the depths of which even the burning sun of the long lunar day would be totally unable to dislodge more than traces of aqueous vapour. A globe of wax was exhibited which had been cast under water; it was highly cellular, and the water had been forced into the hollow spaces, completely filling them. Assuming the solid mass of the moon to contract on cooling at the same rate as granite, its refrigeration through only 180° F. would create cellular space equal to nearly 14½ millions of cubic miles, which would be more than sufficient to engulf the whole of the lunar ocean, supposing it to bear the same proportion to the mass of the moon as our own ocean bears to that of the earth.

If such be the present condition of the moon, we can scarcely avoid the conclusion that a liquid ocean can only exist upon the surface of a

tained a high temperature, the snow-line floated above the summits, possibly even of the most lofty mountains; but with the reduction of oceanic temperature it gradually descended, enveloping peak after peak in a perennial mantle, until during the glacial epoch it attained its lowest depression, whence it again rose, owing to diminished evaporation, to its present position.

The speaker considered, that, inasmuch as recent researches had rendered all previous hypotheses regarding the glacial epoch absolutely untenable, the one for which he now contended could not be said to come into antagonism with any other views. It also further commended itself by requiring the assumption of no natural convulsion or catastrophe, no vast or sudden upheavals or depressions, and no change in the thermal relations of our earth to the sun or to space. On the contrary, it insisted that the glacial epoch was normally and gradually evolved from a thermal condition of the interior of our globe, which could scarcely be said to be any longer the subject of controversy.

In conclusion, this hypothesis suggests the probability that the other bodies belonging to our solar system have either already passed through a similar epoch or are destined still to encounter it. With the exception of the polar ice of Mars we have hitherto obtained no certain glimpse into the thermal or meteorological condition of the planets: neither is the physical state of their surfaces accessible to our best telescopes. It is otherwise however with the moon, whose distance is not too great to prevent the visibility of comparatively minute details. A careful observation of the lunar surface for more than a year with a silvered-glass reflector of 7 inches aperture and of good defining power, had created in the speaker's mind an impression that our satellite had, like its primary, also passed through a glacial epoch, and that several at least of the *valleys*, *rills*, and *streaks* of the lunar surface were not improbably due to former glacial action. Notwithstanding the excellent definition of modern telescopes, it could not be expected that other than the most gigantic of the characteristic details of an ancient glacier bed would be rendered visible. Under favourable circumstances the terminal moraine of a glacier attains to enormous dimensions; and consequently, of all the marks of a glacial valley, this would be the one most likely to be first perceived. Two such terminal moraines, one of them a double one, appeared to him to be traceable upon the moon's surface. The first was situated near the termination of that remarkable streak which commences near the base of Tycho, and passing under the south-eastern wall of Bullialdus, into the ring of which it appears to cut, is gradually lost after passing crater 216 (Lubinietzky). Exactly opposite the last crater, and extending nearly across the streak in question, are two ridges forming the arcs of circles, whose centres are not coincident and whose external curvature is towards the north. Beyond the second ridge a talus slopes gradually down northwards to the general level of the lunar surface, the whole presenting an appearance reminding the observer of the concentric

moraines of the Rhone glacier. These ridges are visible for the whole period during which that portion of the moon's surface is illuminated, but it is only about the third day after the first quarter and at the corresponding phase of the waning moon (when the sun's rays, falling nearly horizontally, throw the details of this part of the surface into strong relief) that these appearances suggest the explanation now offered.

The other ridge, answering to a terminal moraine, occurs at the northern extremity of that magnificent valley which runs past the eastern edge of Rheita. This ridge is nearly semicircular, and is considerably elevated, both above the northern termination of the valley, and the general surface of the moon. It may be seen about four days after new and full moon, but the position of the observer, with regard to the lights and shadows, renders its appearance in the rays of the rising sun by far the most striking.

With regard to the probability of former glacial, or even aqueous, agency on the surface of the moon, difficulties of an apparently very formidable character present themselves. There is not only now no evidence whatever of the presence of water in any one of its three forms, at the lunar surface; but, on the contrary, all seleniographic observations tend to prove its absence. Nevertheless, the idea of former aqueous agency in the moon is by no means new. It was entertained by Gruithuisen and others. But if water at one time existed on the surface of the moon, whither has it disappeared? If we assume, in accordance with the nebular hypothesis, that the portions of matter composing respectively the earth and the moon once possessed an equally elevated temperature, it almost necessarily follows that the moon, owing to the comparative smallness of its mass, would cool much more rapidly than the earth; for whilst the volume of the moon is only about $\frac{1}{49}$th, its surface is nearly $\frac{1}{13}$th, that of the earth.

This cooling of the mass of the moon must, according to all analogy, have been attended with contraction, which can scarcely be conceived as occurring without the development of a cavernous structure in the interior. Much of this cavernous structure would doubtless communicate by means of fissures with the surface, and thus there would be provided an internal receptacle for the ocean, from the depths of which even the burning sun of the long lunar day would be totally unable to dislodge more than traces of aqueous vapour. A globe of wax was exhibited which had been cast under water; it was highly cellular, and the water had been forced into the hollow spaces, completely filling them. Assuming the solid mass of the moon to contract on cooling at the same rate as granite, its refrigeration through only 180° F. would create cellular space equal to nearly 14½ millions of cubic miles, which would be more than sufficient to engulf the whole of the lunar ocean, supposing it to bear the same proportion to the mass of the moon as our own ocean bears to that of the earth.

If such be the present condition of the moon, we can scarcely avoid the conclusion that a liquid ocean can only exist upon the surface of a

planet, so long as the latter retains a high internal temperature. The moon then becomes to us a prophetic picture of the ultimate fate which awaits our earth, when, deprived of an external ocean and of all but a monthly rotation upon its axis,[*] it shall revolve round the sun an arid and lifeless wilderness, — alternately scorched by the protracted glare of a cloudless sun, and chilled by the intense cold of an arctic night.

[E. F.]

GENERAL MONTHLY MEETING,

Monday, February 1, 1864.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Hon. Slingsby Bethell.
Robert George Clarke, Esq.
The Lord Otho Fitz-Gerald.
Jackson Hunt, Esq.
William Senhouse Kirkes, M.D. F.R.C.P.
George Cargill Leighton, Esq.
John Peter, Esq.
David S. Price, Esq Ph.D. F.C.S.
William F. Scholfield, Esq.
William Barrington Tristram, Esq.

were *elected* Members of the Royal Institution.

Edward Henry Moscrop, Esq.
William Stones, Esq.

were *admitted* Members of the Royal Institution.

The Special Thanks of the Members were returned to His Royal Highness The Prince of Wales, for his present of Dr. S. Birch's "Description of the Papyrus of Nas-Khem, Priest of Amen-ra, dised in an Excavation made in a Tomb near Thebes, by direc- of H.R.H. the Prince of Wales, and printed for Private Circula- ' 8vo. 1863.

---

[*] Mayer has recently proved that the action of the tides tends to arrest the motion of the earth upon its axis. And although it has been proved that since the time of Hipparchus the length of the terrestrial day has not increased by the $\frac{1}{100}$th part of a second, yet this fact obviously leaves untouched the conclusion to which Mayer's reasoning leads.

he Special Thanks of the Members were also given to Sir HENRY LAND, Bart. M.D. F.R.S. for his present of an Aneroid Barometer, oyed by Capt. Owen Stanley in his Surveying Voyage on the s of Australia and New Guinea, on board the *Rattlesnake.*

The Secretary announced the following Additions to "the Donation d for the Promotion of Experimental Researches" (*see* page 151).

Mrs. Barlow	£5
Miss E. M. Stooks	5
Thomas Hyde Hills, Esq.	21
Henry Bence Jones, M.D. Hon. Sec. R.I.	20
Professor Wheatstone	50
Harry Mackenzie, Esq	20
Robert P. Roupell, Esq.	20
J. Carrick Moore, Esq.	10 (Annual)

n conformity with the notice given at the Meeting, on Decem- 7, 1863, it was unanimously

RESOLVED, That the following Alterations, or Suspensions, be e in the Bye-Laws of the Royal Institution :—

. That the Bye-Law, Chap. XI. Art. 2, be suspended for the s 1864, 1865, and 1866.

[ART. 2.—The Composition of Members (except the sum of Ten Guineas out of every Composition paid by any Member not having been previously a Life Subscriber, to be carried over to the account of the Laboratory Fund) shall, upon payment thereof, be invested by the Committee of Managers in the public Funds, in the name of the Corporation, in order to form a permanent Fund, the annual dividends of which are to be considered as part of the annual income of the Institution.]

. That the Bye-Law, Chap. XXI. Art. 4, be suspended for the s 1864, 1865, and 1866.

[ART. 2.—The sum of Ten Guineas out of the Composition of every Member not having been previously a Life Subscriber who shall compound for his Annual Payments, pursuant to Articles 6 and 9 of Chapter II., shall be invested in the Funds, and carried to a separate account, to be entitled the Laboratory Fund, the dividends of which shall be appropriated towards the support of the Laboratory.]

. That so much of the Bye-Law, Chap. XXI. Art. 6, as provides the Expenses of the Laboratory be not permitted to exceed the of 400*l.* per annum, be suspended for the years 1864, 1865, and 6.

[ART. 6.—The Dividends and Interest arising from the Laboratory Fund, and the sum of One Guinea per annum out of the Annual Contribution of every Member elected after the fourth day of August, 1823, and of all Members elected previously to that time who shall consent to be charged with the Annual payment of One Guinea in addition to his present Annual payment, for the support of the Laboratory, and all donations to the Laboratory, not amounting to the sum of Ten Guineas, shall be applied in

> the maintenance of the Laboratory, and in paying the Servants and Assistants employed therein, and in providing all the materials used in and about the same, including Coals and Oil. Provided always that the expenses of the Laboratory be not permitted to exceed the sum of 400*l.* per annum.]

4. That the Bye-Law, Chap. XXI. Art. 7, be suspended for the years 1864, 1865, and 1866.

> [ART. 7.—In case the Income appropriated to the support of the Laboratory shall in any year exceed the sum of 400*l.*, the surplus shall be applied to the general purposes of the Institution, in the same manner as the Rents, Revenues, and Annual Income are to be laid out and employed pursuant to Art. 3, of Chapter XI.; provided that nothing herein contained shall prevent the Committee of Managers, in case the Rents, Revenues, and Annual Income of the Institution shall in any year be sufficient to meet the charges and expenses payable out of the same, from employing the surplus of the Income appropriated to the support of the Laboratory, or such part of it as they may deem expedient in and towards the maintenance of the Laboratory.]

The PRESENTS received since the last Meeting were laid on the table and the thanks of the Members returned for the same: viz.:—

FROM

Asiatic Society, Royal—Journal, Vol. XX. Parts 3 & 4. 8vo. 1863.
Aspland, A. Esq. (the Author)—Address to the Manchester Statistical Society. (K 90) 8vo. 1863.
Astronomical Society, Royal—Monthly Notices, 1863–4. Nos. 1, 2.
Bavarian Academy, Royal—Sitzungsberichte, 1863. Band I. Heft 4. Band II. Heft 1. 8vo. 1863.
British Architects, Royal Institute of Proceedings, 1862–3; and Jan. 1864. 4to.
British Meteorological Society—Proceedings, Vol. I. No. 9. 8vo. 1863.
Chambers, George F. Esq. M.R.I. (the Author)—Sussex Tracts. 16to. 1863.
A Parochial Lecture on Astronomy. (K 90) 16to. 1863.
Chemical Society—Journal, 1863. Nos. 12, 13. 1864. No. 1. 8vo.
Churchill, Messrs. (the Publishers)—The Quarterly Journal of Science, No. 1. 8vo. 1864.
Editors—Artizan for Nov. 1863–Jan. 1864. 4to.
Athenæum for Nov. 1863–Jan. 1864. 4to.
Chemical News for Nov. 1863–Jan. 1864. 4to.
Engineer for Nov. 1863–Jan. 1864. fol.
Horological Journal, No. 65. 8vo. 1863.
Journal of Gas-Lighting for Nov. 1863–Jan. 1864. 4to.
Mechanics' Magazine for Nov. 1863—Jan. 1864. 8vo.
Medical Circular for Nov. 1863–Jan. 1864. 8vo.
Practical Mechanics' Journal for Nov. 1863–Jan. 1864. 4to.
Technologist for Nov 1863–Jan. 1864. 8vo.
Faraday, Professor, D.C.L. F.R.S.—Abhandlungen der Akademie der Wissenschaften zu Berlin, 1862. 4to. 1863.
Franklin Institute of Pennsylvania—Journal, Nos. 445, 456. 8vo. 1863.
Geographical Society, Royal—Journal, Vol. XXXII. 8vo. 1863.
Geological Institute, Vienna—Jahrbuch, 1863. No. 3. 8vo.
Gladstone, Dr. J. H. F.R.S. M.R.I.—Report of the British Association Committee on the Application of Gun Cotton to Warlike Purposes. (Report Brit. Assoc. 1863.) 8vo.
Glasgow Philosophical Society—Proceedings, Vol. V. Nos. 2, 3. 8vo. 1862-3.
Henriques, Alfred G. Esq. M.R.I. (the Author)—On some Legal and Economic Questions relating to Land Credit and Mortgage Companies. (K 90) 8vo. 1863.
Horticultural Society, Royal—Proceedings, No. 1. 8vo. 1864.

vons, W. Stanley, Esq. M.A. (*the Author*)—Pure Logic. 16to. 1863.

eeds Literary and Philosophical Society—Annual Report for 1862–3. 8vo.

H. Hennessy:—Essay on the Relations of Science to Modern Civilization. (L 14) 8vo. 1862.

echanical Engineers' Institution, Birmingham—Proceedings, May, 1863. 8vo.

osley, Sir Oswald, Bart. D.C.L. (*the Author*)—The Natural History of Tutbury. 8vo. 1863.

ewton, Messrs.—London Journal (New Series) for Nov. 1863–Jan. 1864. 8vo.

etermann, A. Esq. (*the Editor*)—Mittheilungen aus dem Gesammtgebiete der Geographie. No. 11; and Ergänzungsheft. 4to. 1863.

hotographic Society—Journal, Nos. 140, 141. 8vo. 1863–4.

aumer, M. Friedrich Von, Hon. M.R.I. (*the Author*)—Handbuch zur Geschichte der Litteratur. 2 vols. 12mo. Leipzig, 1864.

oberts, George E. Esq. (*the Author*)—Remarks on the Present Condition of Geological Science. (K 90) 8vo. 1863.

oyal Society of Edinburgh—Transactions, Vol. XXIII. Part 2. 4to. 1863.

Proceedings, Nos. 59–61. 8vo. 1862–3.

oyal Society of Literature—Transactions, Vol. VII. Part 3. 8vo. 1863.

oyal Society of London—Proceedings, No. 58. 1863.

t. Petersbourg Académie Impériale des Sciences—Mémoires, 7me Série. Tome IV. Nos. 10, 11. 4to. 1862.

Bulletins, Tome IV. Nos. 7, 8, 9. Tome V. Nos. 1, 2. 4to. 1862.

illiman, Professors (*the Editors*)—American Journal of Science, No. 108. 8vo. 1863.

tatistical Society—Journal, Vol. XXVI. Part 4. 8vo. 1863.

Index to Vol. XVI–XXV. 8vo. 1863.

aylor, Rev. William, F.R.S. M.R.I.—B. Kennet: Lives of Grecian Poets. 8vo. 1697.

R. Cary: Palæologia Chronica: a Chronological Account of Ancient Time. fol. 1677.

psal Royal Society of Sciences—Nova Acta. Series 3. Vol. IV. Fasc. 2. 4to. 1863.

Upsala Universitets Arsskrift. 1862. 8vo.

allich, G. C. M.D. F.L.S. (*the Author*)—The North Atlantic Sea-bed: comprising a Diary of the Voyage on board H.M.S. *Bulldog*, in 1860. Part 1. 4to. 1862.

Way, Albert, Esq. F.S.A.—A. H. Rhind: Thebes, its Tombs and their Tenants. 8vo. 1862.

Facsimiles of Two Papyri found in a Tomb at Thebes: with a Translation by Dr. S Birch, and an Account of their Discovery by A. H. Rhind. fol. 1863.

orkshire West Riding Geological and Polytechnic Society—Proceedings, 1862. 8vo.

WEEKLY EVENING MEETING,

Friday, February 5, 1864.

Sir Roderick I. Murchison, K.C.B. D.C.L. F.R.S. Vice-President, in the Chair.

J. A. Froude, Esq.

On the Science of History.

Ladies and Gentlemen,—I have undertaken to speak to you this evening on what is called the Science of History. I fear it is a dry subject; and there seems, indeed, something incongruous in the very connection of such words as Science and History. It is as if we were to talk of the colour of sound, or the longitude of the rule-of-three. Where it is so difficult to make out the truth on the commonest disputed fact in matters passing under our very eyes, how can we talk of a science in things long past, which come to us only through books? It often seems to me as if History was like a child's box of letters, with which we can spell any word we please. We have only to pick out such letters as we want, arrange them as we like, and say nothing about those which do not suit our purpose.

I will try to make the thing intelligible, and I will try not to weary you; but I am doubtful of my success either way. First, however, I wish to say a word or two about the eminent person whose name is connected with this way of looking at History, and whose premature death struck us all with such a sudden sorrow. Many of you, perhaps, recollect Mr. Buckle as he stood not so long ago in this place; for he spoke more than an hour without a note—never repeating himself, never wasting words; laying out his matter as easily and as pleasantly as if he had been talking to us at his own fireside. We might think what we pleased of Mr. Buckle's views, but it was plain enough that he was a man of uncommon power; and he had qualities also—qualities to which he, perhaps, himself attached little value: as rare as they were admirable.

Most of us, when we have hit on something which we are pleased to think important and original, feel as if we should burst with it. We come out into the book-market with our wares in hand, and ask for thanks and recognition. Mr. Buckle, at an early age, conceived the thought which made him famous, but he took the measure of his abilities. He knew that whenever he pleased he could command personal distinction, but he cared more for his subject than for himself. He was contented to work with patient reticence, unknown and unheard

or twenty years; and then, at middle life, he produced a work
h called the attention of Europe. Nay, of all places in the world,
uttered the dovecotes of the Imperial Academy of St. Petersburg.
oethe says somewhere, that as soon as a man has done anything
rkable, there seems to be a general conspiracy to prevent him
doing it again. He is feasted, fêted, caressed; his time is stolen
him by breakfasts, dinners, societies, idle businesses of a thousand
s. Mr. Buckle had his share of all this; but there are also more
gerous enemies that wait upon success like his. He had scarcely
for himself the place which he deserved, than his health was found
tered by his labours. He had but time to show us how large a
he was—time just to sketch the outlines of his philosophy, and he
ed away as suddenly as he appeared. He went abroad to recover
ngth for his work, but his work was done with and over. He died
fever at Damascus, vexed only that he was compelled to leave it
mpleted. Almost his last conscious words were, "My book, my
! I shall never finish my book!" He went away as he had lived,
y careless of himself, and thinking only of the thing which he had
rtaken to do.

But his labour had not been thrown away. Disagree with him as
night, the effect which he had already produced was unmistakable,
it is not likely to pass away. What he said was not essentially
. Some such interpretation of human things is as early as the
nning of thought. But Mr. Buckle, on the one hand, had the art
h belongs to men of genius; he could present his opinions with
liar distinctness; and, on the other hand, there is much in the
e of thought at present current among us for which those opinions
an unusual fascination. They do not please us, but they excite
irritate us. We are angry with them; and we betray, in being so,
neasy misgiving that there may be more truth in those opinions
we like to allow.

r. Buckle's general theory was something of this kind: When
an creatures began first to look about them in the world they
d in, there seemed to be no order in anything. Days and nights
e not the same length. The air was sometimes hot and sometimes
l. Some of the stars rose and set like the sun; some were almost
ionless in the sky; some described circles round a central star
e the north horizon. The planets went on principles of their
; and in the elements there seemed nothing but caprice. Sun
moon would at times go out in eclipse. Sometimes the earth
f would shake under their feet; and they could only suppose that
h and air and sky and water were inhabited and managed by
tures as wayward as themselves.

Time went on, and the disorder began to arrange itself. Certain
ences seemed beneficent to men, others malignant and destructive,
the world was supposed to be animated by good spirits and evil
its, who were continually fighting against each other; in outward
re and in human creatures themselves. Finally, as men observed

more and imagined less, these interpretations gave way also. Phenomena the most opposite in effect were seen to be the result of the same natural law. The fire did not burn the house down if the owners of it were careful, but remained on the earth and boiled the pot; nor did it seem more inclined to burn a bad man's house down than a good man's, provided the badness did not take the form of negligence. The phenomena of nature were found for the most part to proceed in an orderly, regular way, and their variations to be such as could be counted upon. From observing the order of things, the step was easy to cause and effect. An eclipse, instead of being a sign of the anger of Heaven, was found the necessary and innocent result of the relative position of sun, moon, and earth. The comets became bodies in space, unrelated to the beings who had imagined that all creation was watching them and their doings. By degrees caprice, volition, all symptoms of arbitrary action, disappeared out of the universe; and almost every phenomenon in earth or heaven was found attributable to some law, either understood or perceived to exist. Thus nature was reclaimed from the imagination. The first fantastic conception of things gave way before the moral; the moral in turn gave way before the natural; and at last there was left but one small tract of jungle where the theory of law had failed to penetrate, the doings and characters of human creatures themselves.

There, and only there, amidst the conflicts of reason and emotion, conscience and desire, spiritual forces were still conceived to exist. Cause and effect were not traceable when there was a free volition to disturb the connection. In all other things, from a given set of conditions, the consequences necessarily followed. With man, the word law changed its meaning; and instead of a fixed order, which he could not choose but follow, it became a moral precept which he might disobey if he dared.

This it was which Mr. Buckle disbelieved. The economy which prevailed throughout nature, he thought it very unlikely should admit of this exception. He considered that human beings acted necessarily from the impulse of outward circumstances upon their mental and bodily condition at any given moment. Every man, he said, acted from a motive; and his conduct was determined by the motive which affected him most powerfully. Every man naturally desires what he supposes to be good for him; but to do well, he must know well. He will eat poison, so long as he does not know that it is poison. Let him see that it will kill him, and he will not touch it. It was no question of moral right and wrong. Once let him be thoroughly made to feel that the thing is destructive, and he will leave it alone by the law of his nature. His virtues are the result of knowledge: his faults the necessary consequence of the want of it. A boy desires to draw. He knows nothing about it; he draws men like trees or houses, with their centre of gravity in the air. He makes mistakes because he knows no better. We do not blame him. Till he is better taught he cannot help it. But his instruction begins. He arrives at straight lines; then at solids; then at curves. He learns perspective, and

;ht and shade. He observes more accurately the forms which he shes to represent. He perceives effects, and he perceives the means which they are produced. He has learned what to do: and, in rt, he has learned how to do it. His after-progress will depend on e amount of force which his nature possesses; but all this is as tural as the growth of an acorn. You do not preach to the acorn at it is its duty to become a large tree; you do not preach to the t-pupil that it is his duty to become a Holbein. You plant your orn in favourable soil, where it can have light and air, and be shel- red from the wind; you remove the superfluous branches, you train e strength into the leading shoots. The acorn will then become as e a tree as it has vital force to become. The difference between en and other things is only in the largeness and vanity of man's pacities; and in this special capacity, that he alone has the power of bserving the circumstances favourable to his own growth, and can apply hem for himself. Yet, again, with this condition,—that he is not, as commonly supposed, free to choose whether he will make use of these ppliances or not. When he knows what is good for him, he *will* hoose it; and he will judge what is good for him by the circumstances which have made him what he is.

And what he would do, he always had done. His history had been a natural growth as much as the growth of the acorn. His improvement had followed the progress of his knowledge; and, by a comparison of his outward circumstances with the condition of his mind, his whole proceedings on this planet, his creeds and constitutions, his good deeds and his bad, his arts and his sciences, his empires and his revolutions, would be found all to arrange themselves into clear relations of cause and effect.

If, when Mr. Buckle pressed his conclusions, we objected the difficulty of finding what the truth about past times really was, he ould admit it candidly as far as concerned individuals; but there was ot the same difficulty, he said, with masses of men. We might dis- gree about the characters of Julius or Tiberius Cæsar, but we could now well enough the Romans of the Empire. We had their literature tell us how they thought; we had their laws to tell us how they verned; we had the broad face of the world, the huge mountainous tline of their general doings upon it, to tell us how they acted. e believed it was all reducible to laws, and could be made as telligible as the growth of the chalk cliffs or the coal measures.

And thus consistently Mr. Buckle cared little for individuals. He d not believe (as some one has said) that the history of mankind is e history of its great men. Great men with him were but larger toms, obeying the same impulses with the rest, only perhaps a trifle ore erratic. With them or without them, the course of things would ave been much the same.

As an illustration of the truth of his view, he would point to the new science of Political Economy. Here already was a large area of human activity in which natural laws were found to act unerringly. Men had gone on for centuries trying to regulate trade on moral principles. They would fix wages according to some imaginary rule of fairness; they would fix prices by what they considered things ought to cost; they encouraged one trade, or discouraged another, for moral reasons. They might as well have tried to work a steam-engine on moral principles. The great statesmen whose names were connected with these enterprises might have as well legislated that water should run up-hill. There were natural laws, fixed in the conditions of things; and to contend against them was the old battle of the Titans against the gods.

As it was with political economy, so it was with all other forms of human activity; and as the true laws of political economy explained the troubles which people fell into in old times, because they were ignorant of them, so the true laws of human nature, as soon as we knew them, would explain the mistakes in more serious matters, and enable us to manage better for the future. Geographical position, climate, air, soil, and the like, had their several influences. The northern nations are hardy and industrious, because they must till the earth if they would eat the fruits of it, and because the temperature is too low to make an idle life enjoyable. In the south, the soil is more productive, while less food is wanted and fewer clothes; and in the exquisite air, exertion is not needed to make the sense of existence delightful. Therefore, in the south, we find men lazy and indolent.

True, there are difficulties in these views: the home of the languid Italian was the home also of the sternest race of whom the story of mankind retains a record. And again, when we are told that the Spaniards were superstitious, because Spain was a country of earthquakes, we remember Japan, the spot in all the world where earthquakes are most frequent, and where at the same time there is the most serene disbelief in any supernatural agency whatsoever.

Moreover, if men grow into what they are by natural laws, they cannot help being what they are; and if they cannot help being what they are, a good deal will have to be altered in our general view of things.

That, however, in these theories there is a great deal of truth is quite certain; were there but a hope that those who maintain them would be contented with that admission. A man born in a Mahometan country grows up a Mahometan; in a Catholic country, a Catholic; in a Protestant country, a Protestant. His opinions are like his language; he learns to think as he learns to speak; and it is absurd to suppose him responsible for being what nature makes him. We take pains to educate children. There is a good education and a bad education; there are rules well ascertained by which characters are influenced, and, clearly enough, it is no mere matter for a boy's free will whether he turns out well or ill. We try to train him into d habits; we keep him out of the way of temptations; we see that is well taught; we mix kindness and strictness; we surround him h every good influence we can command. These are what are ned the advantages of a good education; and if we fail to provide se under our care with it, and if they go wrong, the responsibility feel is as much ours as theirs. This is at once an admission of the wer over us of outward circumstances.

In the same way, we allow for the strength of temptations, and e like.

In general, it is perfectly obvious that men do necessarily absorb, t of the influence in which they grow up, what gives a complexion their whole after-character.

When historians have to relate great social or speculative changes, e overthrow of a monarchy or the establishment of a creed, they o but half their duty if they merely relate the events. In an account, r instance, of the rise of Mahometanism, it is not enough to describe he character of the Prophet, the ends which he set before him, the means which he made use of, and the effect which he produced; the historian must show what there was in the condition of the Eastern races which enabled Mahomet to act upon them so powerfully; their existing beliefs, their existing moral and political condition.

In our estimate of the past, and in our calculations of the future—in the judgments which we pass upon one another, measuring responsibility, not by the thing done, but by the opportunities which people have had of knowing better or worse—in the efforts which we make to keep our children from bad associations or friends—we admit that external circumstances have a powerful effect in making men what they are.

But are circumstances everything? That is the whole question. A science of history, if it is more than a misleading name, implies that the relation between cause and effect holds in human things as in all others, that the origin of human actions is not to be looked for in mysterious properties of the mind, but in influences which are palpable and ponderable.

When natural causes are liable to be set aside and neutralized by what is called volition, the word Science is out of place. If it is free to a man to choose what he will do or not do, there is no science of him. If there is a science of him, there is no free choice, and the praise or blame with which we regard one another is impertinent and out of place.

I am trespassing upon these ethical grounds, because unless I do, the subject cannot be made intelligible. Mankind is but an aggregate of individuals—History is but the record of individual action, and what is true of the part, is true of the whole.

We feel keenly about such things, and when the logic becomes perplexing, we are apt to grow rhetorical about them. It is a bad plan however. Whatever the truth may be, it is best that we should know it; and for truth of any kind we should keep our heads and hearts as cool as we can.

I will say at once, that if we had the whole case before us—if we were taken, like Leibnitz's Tarquin, into the council chamber of nature, and were shown what we really were, where we came from, and where we were going, however unpleasant it might be for some of us to find ourselves, like Tarquin, made into villains, from the subtle necessities of "the best of all possible worlds;" nevertheless some such theory as Mr. Buckle's might possibly turn out to be true. Likely enough, there is some great "equation of the universe" when the value of the unknown quantities can be determined. But we must treat things in relation to our own powers and position; and the question is, whether the sweep of those vast curves can be measured by the intellect of creatures of a day like ourselves.

The 'Faust' of Goethe, tired of the barren round of earthly knowledge, calls magic to his aid. He desires, first, to see the spirit of the Macrocosmos, but his heart fails him before he ventures that tremendous experiment, and he summons before him, instead, the spirit of his own planet. There he feels himself at home. The stream of life and the storm of action, the everlasting ocean of existence, the web and the woof, and the roaring loom of time: he gazes upon it, and in passionate exultation claims fellowship with the awful thing before him. But the majestic vision fades, and a voice comes to him—"Thou art fellow with the spirits which thy mind can grasp—not with me."

Had Mr. Buckle tried to follow his principles into detail, it might have gone no better with him than with 'Faust.'

What are the conditions of a science? and when may any subject be said to enter the scientific stage? I suppose when the facts of it begin to resolve themselves into groups; when phenomena are no longer isolated experiences, but appear in connection and order; when, after certain antecedents, certain consequences are seen to follow; when facts enough have been collected to furnish a basis for conjectural explanation, and when conjectures have so far ceased to be utterly vague, that it is possible in some degree to foresee the future by the help of them.

Till a subject has advanced as far as this, to speak of a science of it is an abuse of language. It is not enough to say that there must be a science of human things, because there is a science of all other things. This is like saying the planets must be inhabited, because the only planet of which we have any experience is inhabited. It may or may not be true, but it is not a practical question; it does not affect the practical treatment of the matter in hand.

Let us look at the history of Astronomy.

So long as sun, moon, and planets were supposed to be gods or angels; so long as the sword of Orion was not a metaphor, but a fact;

;roups of stars which inlaid the floor of heaven were the trophies of the loves and wars of the Pantheon, so long there ience of Astronomy. There was fancy, imagination, poetry, everence, but no science. As soon, however, as it was ob- t the stars retained their relative places, that the times of g and setting varied with the seasons, that sun, moon, and oved among them in a plane, and the belt of the Zodiac was t and divided, then a new order of things began. Traces of r stage remained in the names of the signs and constellations, Scandinavian mythology survives now in the names of the e week: but for all that, the understanding was now at work ing; Science had begun, and the first triumph of it was the foretelling the future; eclipses were perceived to recur in nineteen years, and philosophers were able to say when an s to be looked for. The periods of the planets were deter- Theories were invented to account for their eccentricities; as those theories might be, the position of the planets could ited with moderate certainty by them. The very first result ence, in its most imperfect stage, was a power of foresight; vas possible before any one true astronomical law had been l.

hould not therefore question the possibility of a science of ecause the explanations of its phenomena were rudimentary ect; that they might be, and might long continue to be, and h might be done to show that there was such a thing, and s not entirely without use. But how was it that in those rude small knowledge of mathematics, and with no better instru- n flat walls and dial plates, those first astronomers made so considerable? Because, I suppose, the phenomena which observing recurred, for the most part, within moderate so that they could collect large experience within the of their natural lives: because days and months and years surable periods, and within them the more simple phenomena ly repeated themselves.

ow would it have been if, instead of turning on its axis once -four hours, the earth had taken a year about it; if the year nearly four hundred years; if man's life had been no longer , and for the initial steps of astronomy there had been nothing l upon except observations recorded in history? How long have been, had this been our condition, before it would have to any one that, in what they saw night after night, there kind of order at all?

n see to some extent how it would have been, by the present hose parts of the science which in fact depend on remote re- servations. The movements of the comets are still extremely . The times of their return can be calculated only with the agueness.

yet such a hypothesis as I have suggested would but inadequately express the position in which we are in fact placed tow history. There the phenomena never repeat themselves. There are dependent wholly on the record of things said to have happe once, but which never happen or can happen a second time. Th no experiment is possible; we can watch for no recurring fact to t the worth of our conjectures. It has been suggested, fancifully, t if we consider the universe to be infinite, time is the same as eterni and that the past is perpetually present. Light takes nine years come to us from Sirius; those rays which we may see to-night wh we leave this place, left Sirius nine years ago; and could the inhal ants of Sirius see the earth at this moment, they would see the Engl army in the trenches before Sebastopol: Florence Nightingale wat ing at Scutari over the wounded at Inkermann; and the peace England undisturbed by "Essays and Reviews."

As the stars recede into distance, so time recedes with them, a there may be, and probably are, stars from which Noah might be s stepping into the ark, Eve listening to the temptation of the serpe or that older race, who ate the oysters and left the shell-heaps behi them, when the Baltic was an open sea

Could we but compare notes, something might be done; but of t there is no present hope, and without it there will be no science history. Eclipses, recorded in ancient books, can be verified by calc lation, and lost dates can be recovered by them, and we can foresee the laws which they follow when there will be eclipses again. Wil time ever be when the lost secret of the foundation of Rome can recovered by historic laws? If not, where is our science? It may said that this is a particular fact, that we can deal satisfactorily w general phenomena affecting eras and cycles. Well, then let us t some general phenomenon. Mahometanism, for instance, or Buddhis Those are large enough. Can you imagine a science which would ha FORETOLD such movements as those? The state of things out of wh they rose is obscure; but suppose it not obscure, can you conce that, with any amount of historical insight into the old Oriental belie you could have seen that they were about to transform themselves i those particular forms and no other?

It is not enough to say, that, after the fact, you can understa partially how Mahometanism came to be. All historians wo the name have told us something about that: but when we talk science, we mean something with more ambitious pretences, we me something which can foresee as well as explain; and, thus looked to state the problem is to show its absurdity. . . . As little could wisest man have foreseen this mighty revolution, as thirty years a such a thing as Mormonism could have been anticipated in Americ as little as it could have been foreseen that table-turning and spi rapping would have been an outcome of the scientific culture England in the nineteenth century.

The greatest of Roman thinkers, gazing mournfully at the seethi ss of moral putrefaction round him, detected and deigned to notice mong its elements a certain detestable superstition, so he called it, ing up amidst the off-scouring of the Jews, which was named hristianity. Could Tacitus have looked forward nine centuries to e Rome of Gregory VII., could he have beheld the representative of e majesty of the Cæsars holding the stirrup of the Pontiff of that ile and execrated sect, the spectacle would scarcely have appeared to im the fulfilment of a rational expectation, an intelligible result of e causes in operation round him. Tacitus, indeed, was born before e science of history; but would M. Comte have seen any more learly?

Nor is the case much better if we are less hard upon our philophy; if we content ourselves with the past, and require only a cientific explanation of that.

First, for the facts themselves. They come to us through the minds f those who recorded them, neither machines nor angels, but fallible reatures, with human passions and prejudices. Tacitus and Thucyides were perhaps the ablest men who ever gave themselves to writing istory; the ablest, and also the most incapable of conscious falsehood. et even now, after all these centuries, the truth of what they relate s called in question. Good reasons can be given to show that neither f them can be confidently trusted. If we doubt with these, whom are e to believe?

Or again, let the facts be granted. To revert again to my simile of he box of letters, you have but to select such facts as suit you, you ave but to leave alone those which do not suit you, and let your heory of history be what it will, you can find no difficulty in providing acts to prove it.

You may have your Hegel's philosophy of history, or you may have our Schlegel's philosophy of history; you may prove from history that he world is governed in detail by a special Providence; you may prove that there is no sign of any moral agent in the universe, except man; you may believe, if you like it, in the old theory of the wisdom f antiquity; you may speak, as was the fashion in the fifteenth century, of "our fathers, who had more wit and wisdom than we;" or you may talk of "our barbarian ancestors," and describe their wars as the scuffling of kites and crows.

You may maintain that the evolution of humanity has been an unbroken progress towards perfection; you may maintain that there has been no progress at all, and that man remains the same poor creature that he ever was; or, lastly, you may say with the author of the 'Contrat Social,' that men were purest and best in primeval implicity—

"When wild in woods the noble savage ran."

In all or any of these views, history will stand your friend. History, in its passive irony, will make no objection. Like Jarno, in Goethe's novel, it will not condescend to argue with you, and will

provide you with abundant illustrations of anything which you
wish to believe.

"What is history," said Napoleon, "but a fiction agreed upo
"My friend," said Faust to the student, who was growing enthusi
about the spirit of past ages; "my friend, the times which are
are a book with seven seals; and what you call the spirit of past
is but the spirit of this or that good gentleman in whose mind
ages are reflected."

One lesson, and only one, history may be said to repeat with
tinctness; that the world is built somehow on moral foundations;
in the long run, it is well with the good; in the long run, it is ill
the wicked. But this is no science; it is no more than the old doct
taught long ago by the Hebrew prophets. The theories of M. Co
and his disciples advance us, after all, not a step beyond the trod
and familiar ground. If men are not entirely animals, they are
least half animals, and are subject in this aspect of them to the
ditions of animals. So far as those parts of man's doings are concern
which neither have nor need have anything moral about them, so
the laws of him are calculable. There are laws for his digestion,
laws of the means by which his digestive organs are supplied
matter. But pass beyond them, and where are we? In a world wh
it would be as easy to calculate men's actions by laws like those
positive philosophy as to measure the orbit of Neptune with a f
rule, or weigh Sirius in a grocer's scale.

And it is not difficult to see why this should be. The first p
ciple on which the theory of a science of history can be plausi
argued, is that all actions whatsoever arise from self-interest. It
be enlightened self-interest; it may be unenlightened; but it
assumed as an axiom, that every man, in whatever he does, is aim
at something which he considers will promote his happiness.
conduct is not determined by his will; it is determined by the obj
of his desire. Adam Smith, in laying the foundations of politi
economy, expressly eliminates every other motive. He does not
that men never act on other motives; still less that they never co
to act on other motives; but merely that, as far as the arts of p
duction are concerned and of buying and selling, the action of
interest may be counted upon as uniform. What Adam Smith
of political economy, Mr. Buckle would extend over the whole ci
of human activity.

Now, that which especially distinguishes a high order of man f
a low order of man—that which constitutes human goodness, hu
greatness, human nobleness—is surely not the degree of enlighten
with which they pursue their own advantage; but it is self-forget
ness—it is self-sacrifice—it is the disregard of personal pleas
personal indulgence, personal advantages remote or present, becau
some other line of conduct is more right.

We are sometimes told that this is but another way of expres the same thing; that when a man prefers doing what is right, it is only because to do right gives him a higher satisfaction. It appears to me, on the contrary, to be a difference in the very heart and nature of things. The martyr goes to the stake, the patriot to the scaffold, not with a view to any future reward to themselves, but because it is a glory to fling away their lives for truth and freedom; and so through all phases of existence, to the small details of common life, the beautiful character is the unselfish character. Those whom we most love and admire are those to whom the thought of self seems never to occur; who do simply and with no ulterior aim—with no thought whether it will be pleasant to themselves or unpleasant—that which is good, and right, and generous.

Is this still selfishness, only more enlightened? I do not think so. The essence of true nobility is neglect of self. Let the thought of self pass in, and the beauty of a great action is gone—like the bloom from a soiled flower. Surely it is a paradox to speak of the self-interest of a martyr who dies for a cause, the triumph of which he will never enjoy; and the greatest of that great company in all ages would have done what they did, had their personal prospects closed with the grave. Nay, there have been those so zealous for some glorious cause, as to wish themselves blotted out of the book of Heaven if the cause of Heaven could succeed.

And out of this mysterious quality, whatever it be, arise the higher relations of human life, the higher modes of human obligation. Kant, the philosopher, used to say that there were two things which overwhelmed him with awe as he thought of them. One was the star-sown deep of space, without limit and without end; the other was right and wrong. Right, the sacrifice of self to good; wrong, the sacrifice of good to self;—not graduated objects of desire, to which we are determined by the degrees of our knowledge, but wide asunder as pole and pole, as light and darkness. One, the object of infinite love; the other, the object of infinite detestation and scorn. It is in this marvellous power in men to do wrong—(it is an old story, but none the less true for that)—it is in this power to do wrong—wrong or right, as it lies somehow with ourselves to choose—that the impossibility stands of forming scientific calculations of what men will do before the fact, or scientific explanations of what they have done after the fact. If men were consistently selfish, you might analyze their motives; if they were consistently noble, they would express in their conduct the laws of the highest perfection. But so long as two natures are mixed together, and the strange creature which results from the combination is now under one influence and now under another, so long you will make nothing of him except from the old-fashioned moral—or, if you please, imaginative—point of view.

Even the laws of political economy itself cease to guide us when they touch moral government. So long as labour is a chattel to be bought and sold, so long, like other commodities, it follows the condition of supply and demand. But if, for his misfortune, an employer considers that he stands in human relations towards his workmen; let him believe, rightly or wrongly, that he is responsible for them; that in return for their labour he is bound to see that their children are decently taught, and they and their families decently fed and clothed and lodged; that he ought to care for them in sickness and in old age; then political economy will no longer direct him, and the relations between himself and his workmen will have to be arranged on quite other principles.

So long as he considers only his own material profit, so long supply and demand will settle every difficulty; but the introduction of a new factor spoils the equation.

And it is precisely in this debatable ground of low motives and noble emotions—in the struggle ever failing, yet ever renewed, to carry truth and justice into the administration of human society; in the establishment of states and in the overthrow of tyrannies; in the rise and fall of creeds; in the world of ideas; in the character and deeds of the great actors in the drama of life; when good and evil fight out their everlasting battle, now ranged in opposite camps, now and more often in the heart, both of them, of each living man—that the true human interest of history resides. The progress of industries, the growth of material and mechanical civilization, are interesting, but they are not the most interesting. They have their reward in the increase of material comforts; but, unless we are mistaken about our nature, they do not highly concern us after all.

Once more; not only is there in men this baffling duality of principle, but there is something else in us which still more defies scientific analysis.

Mr. Buckle would deliver himself from the eccentricities of this strict individual by a doctrine of averages; though he cannot tell whether A, B, or C, will cut his throat, he may assure himself that one man in every fifty thousand, or thereabout (I forget the exact proportion), will cut his throat, and with this he consoles himself. No doubt it is a comforting discovery. Unfortunately, the average of one generation will not be the average of the next. We may be converted by the Japanese, for all that we know; and the Japanese methods of taking leave of life may become fashionable among us. Nay, did not Novalis suggest that the whole race of men would at last become so disgusted with their impotence, that they would extinguish themselves by a simultaneous act of suicide, and make room for a better order of beings. Anyhow, the fountain out of which the race is flowing perpetually changes—no two generations are alike. Whether there is a change in the organization itself, we cannot tell; but this is certain, that as the planet varies with the atmosphere which it inhales, so each new generation varies from the last, because it inhales as its atmosphere the accumulated experience and knowledge of the whole past of the world. These things form the spiritual air which we breathe as 'e grow; and in the infinite multiplicity of elements of which that ir is now composed, it is for ever matter of conjecture what the minds rill be like which expand under its influence.

From the England of Fielding and Richardson to the England f Miss Austen, from the England of Miss Austen to the England of ailways and Free-trade, how vast the change; yet perhaps Sir harles Grandison would not seem so strange to us now, as one of urselves would seem to our great-grandchildren. The world moves aster and faster; and the interval will probably be considerably reater.

The temper of each new generation is a continual surprise. The ates delight to contradict our most confident expectations. Gibbon elieved that the era of conquerors was at an end. Had he lived out he full life of man, he would have seen Europe at the feet of apoleon. But a few years ago we believed the world had grown too ivilized for war, and the Crystal Palace in Hyde Park was to be the nauguration of a new era. Battles, bloody as Napoleon's, are now he familiar tale of every day; and the arts which have made greatest rogress are the arts of destruction. What next? We may strain ur eyes into the future, which lies beyond this waning century; but ever was conjecture more at fault. It is blank darkness, which even he imagination fails to people.

What, then, is the use of History? and what are its lessons? If it an tell us little of the past, and nothing of the future, why waste our ime over so barren a study?

First, it is a voice for ever sounding across the centuries the laws f right and wrong. Opinions alter, manners change, creeds rise and all, but the moral law is written on the tablets of eternity. For every alse word or unrighteous deed, for cruelty and oppression, for lust or anity, the price has to be paid at last: not always by the chief ffenders, but paid by some one. Justice and truth alone endure nd live. Injustice and falsehood may be long-lived, but doomsday omes at last to them, in French revolutions and other terrible ays.

That is one lesson of History. Another is, that we should draw o horoscopes; that we should expect little, for what we expect will ot come to pass. Revolutions, reformations—those vast movements nto which heroes and saints have flung themselves, in the belief that hey were the dawn of the millennium—have not borne the fruit hich they looked for. Millenniums are still far away. These great onvulsions leave the world changed—perhaps improved,—but not mproved as the actors in them hoped it would be. Luther would ave gone to work with less heart, could he have foreseen the Thirty ears' War, and in the distance the theology of Tubingen. Washington might have hesitated to draw the sword against England, could he ave seen the country which he made as we see it now.

The most reasonable anticipations fail us—antecedents the most pposite mislead us; because the conditions of human problems never repeat themselves. Some new feature alters everything—some feature which we detect only in its after-operation.

But this, it may be said, is but a meagre outcome. Can the long records of humanity, with all its joys and sorrows, its sufferings and its conquests, teach us no more than this? Let us approach the subject from another side.

If you were asked to point out the special features in which Shakespeare's plays are so transcendently excellent, you would mention, perhaps, among others, this, that his stories are not put together, and his characters are not conceived, to illustrate any particular law or principle. They teach many lessons, but not any one prominent above another; and when we have drawn from them all the direct instruction which they contain, there remains still something unresolved—something which the artist gives, and which the philosopher cannot give.

It is in this characteristic that we are accustomed to say Shakespeare's supreme *truth* lies. He represents real life. His dramas teach as life teaches—neither less nor more. He builds his fabrics as nature does, on right and wrong; but he does not struggle to make nature more systematic than she is. In the subtle interflow of good and evil—in the unmerited sufferings of innocence—in the disproportion of penalties to desert—in the seeming blindness with which justice, in attempting to assert itself, overwhelms innocent and guilty in a common ruin—Shakspeare is true to real experience. The mystery of life he leaves as he finds it; and, in his most tremendous positions, he is addressing rather the intellectual emotions than the understanding,—knowing well that the understanding in such things is at fault, and the sage as ignorant as the child.

Only the highest order of genius can represent nature thus. An inferior artist produces, if he tries it, something entirely immoral, where good and evil are names, and nobility of disposition is supposed to show itself in the absolute disregard of them. Otherwise, if he is a better kind of man, he will force on nature a didactic purpose. He composes what are called moral tales, which may edify the conscience, but only mislead the intellect.

The finest work of this kind produced in modern times is Lessing's play of 'Nathan the Wise.' The object of it is to teach religious toleration. The doctrine is admirable—the mode in which it is enforced is interesting; but it has the fatal fault, that it is not true. Nature does not teach religious toleration by any such direct method, and the result is—no one knew it better than Lessing himself—that the play is not poetry, but only splendid manufacture. Shakespeare is eternal; Lessing's 'Nathan' will pass away with the mode of thought which gave it birth. One is based on fact; the other, on human theory about fact. The theory seems at first sight to contain the most immediate instruction; but it is not really so.

Cibber and others, as you know, wanted to alter Shakespeare.

The French king, in 'Lear,' was to be got rid of; Cordelia was to marry Edgar, and Lear himself was to be rewarded for his sufferings by a golden old age. They could not bear that Hamlet should suffer for the sins of Claudius. The wicked king was to die, and the wicked mother; and Hamlet and Ophelia were to make a match of it, and live happily ever after. A common novelist would have arranged it so; and you would have had your comfortable moral that wickedness was fitly punished, and virtue had its due reward, and all would have been well. But Shakespeare would not have it so. Shakespeare knew that crime was not so simple in its consequences, or Providence so paternal. He was contented to take the truth from life; and the effect upon the mind of the most correct theory of what life ought to be, compared to the effect of the life itself, is infinitesimal in comparison. Again, if we compare the popular historical treatment of remarkable incidents with Shakespeare's treatment of them. Look at 'Macbeth.' You may derive abundant instruction from it—instruction of many kinds. There is a moral lesson of profound interest in the steps by which a noble nature glides to perdition. In more modern fashion you may speculate, if you like, on the political conditions represented there, and the temptation presented in absolute monarchies to unscrupulous ambition; you may say, like Doctor Slop, these things could not have happened under a constitutional government; or, again, you may take up your parable against superstition—you may dilate on the frightful consequences of a belief in witches, and reflect on the superior advantages of an age of schools and newspapers. If the bare facts of the story had come down to us from a chronicler, and an ordinary writer of the nineteenth century had had to relate them, his account, we may depend upon it, would have been put together upon one or other of these principles. Yet, by the side of that unfolding of the secrets of the prison-house of the soul, what lean and shrivelled anatomies the best of such descriptions would seem!

Shakespeare himself, I suppose, could not have given us a theory of what he meant—he gave us the thing itself on which we might make whatever theories we pleased.

Or again, look at Homer.

The 'Iliad' is from two to three thousand years older than 'Macbeth,' and yet it is as fresh as if it had been written yesterday. We have there no lessons save in the emotions which rise in us as we read. Homer had no philosophy; he never struggles to impress upon us his views about this or that; you can scarcely tell indeed whether his sympathies are Greek or Trojan; but he represents to us faithfully the men and women among whom he lived. He sang the Tale of Troy, he touched his lyre, he drained the golden beaker in the halls of men like those on whom he was conferring immortality. And thus, although no Agamemnon, king of men, ever led a Grecian fleet to Ilium, though no Priam sought the midnight tent of Achilles, though Ulysses and

Diomed and Nestor were but names, and Helen but a dream, yet, through Homer's power of representing men and women, those old Greeks will still stand out from amidst the darkness of the ancient world with a sharpness of outline which belongs to no period of history, except the most recent. For the mere hard purposes of history the 'Iliad' and 'Odyssey' are the most effective books which ever were written. We see the Hall of Menelaus, we see the garden of Alcinous, we see Nausicaa among her maidens on the shore, we see the mellow monarch sitting with ivory sceptre in the Market-place dealing out genial justice. Or again, when the wild mood is on, we can hear the crash of the spears, the rattle of the armour as the heroes fall, and the plunging of the horses among the slain. We could enter the palace of an old Ionian lord, we know what we should see there, we know the words in which he would address us. We could meet Hector as a friend. If we could choose a companion to spend an evening with over a fireside, it would be the man of many counsels, the husband of Penelope.

I am not going into the vexed question whether History or Poetry is the more true. It has been sometimes said that Poetry is the more true, because it can make things more like what our moral sense would prefer they should be. We hear of poetic justice and the like, as if nature and fact were not just enough.

I entirely dissent from that view. So far as Poetry attempts to improve on truth in that way, so far it abandons truth, and is false to itself. Even literal facts, exactly as they were, a great poet will prefer when he can get them. Shakespeare in the historical plays is studious, wherever possible, to give the very words which he finds to have been used; and it shows how wisely he was guided in this, that those magnificent speeches of Wolsey are taken exactly, with no more change than the metre made necessary, from Cavendish's Life. Marlborough read Shakespeare for English history, and read nothing else. The poet only is not bound, when it is inconvenient, to what may be called the accidents of facts. It was enough for Shakespeare to know that Prince Hal in his youth had lived among loose companions, and the tavern in Eastcheap came in to fill out his picture; although Mrs. Quickly and Falstaff, and Poins and Bardolph were more likely to have been fallen in with by Shakespeare himself at the Mermaid, than to have been comrades of the true Prince Henry. It was enough for Shakespeare to draw real men, and the situation, whatever it might be, would sit easy on them. In this sense only it is that Poetry is truer than History, that it can make a picture more complete. It may take liberties with time and space, and give the action distinctness by throwing it into more manageable compass.

But it may not alter the real conditions of things, or represent life as other than it is. The greatness of the poet depends on his being true to nature, without insisting that nature shall theorize with him, without making her more just, more philosophical, more moral than ality; and, in difficult matters, leaving much to reflection which nnot be explained.

And if this be true of Poetry, if Homer and Shakespeare are what ey are, from the absence of everything didactic about them, may we t thus learn something of what history should be, and in what sense should aspire to teach?

If Poetry must not theorize, much less should the historian theo-ze, whose obligations to be true to fact are even greater than the oet's. If the drama is grandest when the action is least explicable by ws, because then it best resembles life, then history will be grandest lso under the same conditions. 'Macbeth,' were it literally true, would e perfect history; and so far as the historian can approach to that ind of model, so far as he can let his story tell itself in the deeds and ords of those who act it out, so far is he most successful. His work no longer the vapour of his own brain, which a breath will scatter; is the thing itself, which will have interest for all time. A thousand eories may be formed about it—spiritual theories, Pantheistic theories, use and effect theories; but each age will have its own philosophy history, and all these in turn will fail and die. Hegel falls out of ate, Schlegel falls out of date, and Comte in good time will fall out f date. The thought about the thing must change as we change, but e thing itself can never change; and a history is durable or perish-ble as it contains more or least of the writer's own speculation. The lendid intellect of Gibbon for the most part kept him true to e right course in this; yet the philosophical chapters for which he s been most admired or censured may hereafter be thought the st interesting in his work. The time has been when they would t have been comprehended; the time may come when they will seem mmonplace.

It may be said, that in requiring history to be written like a rama, we require an impossibility.

For history to be written with the complete form of a drama, doubt-s is impossible; but there are periods, and these the periods, for e most part, of greatest interest to mankind, the history of which ay be so written that the actors shall reveal their characters in their n words; where mind can be seen matched against mind, and the reat passions of the epoch not simply be described as existing, but e exhibited at their white heat in the souls and hearts possessed by em. There are all the elements of drama—drama of the highest rder—where the huge forces of the times are as the Grecian destiny, d the power of the man is seen either stemming the stream till it verwhelms him, or ruling while he seems to yield to it.

It is nature's drama—not Shakespeare's—but a drama none the ss.

So at least it seems to me. Wherever possible, let us not be told bout this man or that. Let us hear the man himself speak; let us e him act, and let us be left to form our own opinions about him. he historian, we are told, must not leave his readers to themselves.

He must not only lay the facts before them—he must tell them what he himself thinks about those facts. In my opinion this is precisely what he ought not to do. Bishop Butler says somewhere, that the best book which could be written would be a book consisting only of premises, from which the readers should draw conclusions for themselves. The highest poetry is that very thing, and the highest history ought to be; and then we shall no more ask for a theory of this or that period of history, than we should ask for a theory of 'Macbeth' or 'Hamlet.' Philosophies of history, sciences of history—all these, there will continue to be; but the fashions of them will change, as our habits of thought will change. Each new philosopher will find his chief employment in showing that before him no one understood anything. But the drama of history is imperishable, and the lessons of it will be like what we learn from Homer or Shakespeare—lessons for which we have no words.

The address of history is less to the understanding than to the higher emotions: we learn in it to sympathize with what is great and good; we learn to hate what is base. In the anomalies of fortune we feel the mystery of our mortal existence, and in the companionship of the illustrious natures who have shaped the fortunes of the world, we escape from the littlenesses which cling to the round of common life, and our minds are tuned in a higher and nobler key.

For the rest, and for those large questions which I touched in connection with Mr. Buckle, we live in times of change, and none can tell what will be after us. What opinions—what convictions—the infant of to-day will find prevailing on the earth, if he and it live out together to the middle of another century, only a very bold man would undertake to conjecture! "The time will come," said Lichtenberg, in scorn at the materializing tendencies of modern thought; "the time will come when the belief in God will be as the tale with which old women frighten children; when the world will be a machine, the ether a gas, and God will be a force." But whether the end be seventy years hence, or seven hundred—be the close of the mortal history of humanity as far distant in the future as its shadowy beginnings seem now to lie behind us—this only we may foretell with confidence,—that the riddle of man's nature will remain unsolved. There will be that in him yet which physical laws will fail to explain—that something, whatever it be, in himself and in the world, which science cannot fathom, and which suggests the unknown possibilities of his origin and his destiny. There will remain yet

> Those obstinate questionings
> Of sense and outward things;
> Falling from us, vanishings—
> Blank misgivings of a creature
> Moving about in worlds not realized,
> High instincts, before which our mortal nature
> Doth tremble like a guilty thing surprised.

s will remain

> Those first affections—
> Those shadowy recollections—
> Which, be they what they may,
> Are yet the fountain-light of all our day—
> Are yet the master-light of all our seeing—
> Uphold us, cherish, and have power to make
> Our noisy years seem moments in the being
> Of the Eternal Silence.

[J. A. F.]

WEEKLY EVENING MEETING,

Friday, February 12, 1864.

HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. Vice-President,
in the Chair.

J. ALFRED WANKLYN, Esq.
PROFESSOR OF CHEMISTRY, LONDON INSTITUTION.

On the Synthesis of Organic Bodies.

ais tray you will see a collection of well-known substances.* Com- these substances with one another, and you will be struck with dissimilarities. Some are solids and crystalline and brittle, s are liquids which are more fluid than water. Some are without rs; others are highly coloured, and are used for dyeing. Some weet, others are bitter; some have delightful perfumes, others dreadful smells; some are wholesome food, others the most rful poisons known to man.

n spite of this wonderful diversity in their properties, all the mens on this tray are compounds of carbon, with a very few ents. Carbon, hydrogen, oxygen, and nitrogen are the only ents which occur in this collection of substances. Some of these ances contain carbon and hydrogen; some contain carbon, hydrogen, xygen; some, carbon, hydrogen, and nitrogen, and some again in carbon, hydrogen, oxygen, and nitrogen. But not one of the mens on this tray contains anything besides these four elements.

here is no difficulty in resolving any one of these substances into timate elements. This sugar,† for example, on being heated to ss in a tube, leaves a black deposit which is carbon, whilst a l which is water distils over. If we were to electrolyse this l, we should obtain hydrogen and oxygen, and so we should it carbon, hydrogen, and oxygen obtained from sugar. Again,

---

A tray, with a number of organic bodies lying upon it, was before the er.

Cane sugar was heated to redness in a tube.

instead of heating this sugar in the tube without allowing the air access to it, we might burn it in excess of oxygen. If we were t so, we should obtain carbonic acid and water, and, moreover, all carbon in the sugar would assume the form of carbonic acid, and the hydrogen the form of water. So we can obtain carbo hydrogen, either in the free state, or in the very common and known forms of combination as carbonic acid and water. Nitro when it is present, can be made to assume the form of free nitro For that purpose, all that is requisite is to heat the substance to ness with excess of oxygen, and to adopt certain precautions to a the production of oxide of nitrogen.

Thus, the pulling to pieces of these substances on the tray matter of very little difficulty: more than fifty years ago che could do that—but how to put the pieces together again is a much difficult task.

Sugar consists of 72 parts by weight of carbon, 11 parts of hydro and 88 parts of oxygen. We may bring together carbon, hydro and oxygen in these proportions, and shake them up together, or them or cool them, and yet we shall never get them to combine to form sugar. Alcohol consists of 24 parts of carbon, 6 part hydrogen, and 16 parts of oxygen, but no alcohol ever results making such a mixture. Neither sugar nor alcohol can exist at temperature to which it is requisite to raise our mixture of car hydrogen, and oxygen, in order to get chemical action to set in. ordinary temperature the organic elements will not enter into co nation, whilst at high temperatures they combine, it is true, but comparatively very few compounds.

It was long after chemists had effected the analysis of org bodies before they learnt how to effect the synthesis of even o them, and hence the belief sprung up that organic products, suc those on our tray, were intrinsically different from mineral prod Whilst stones, water, and the like were regarded as having their ulti particles held together by mere dead forces, sugar, alcohol, &c., regarded as being held together by vital forces, as being in sho some subordinate way, alive.

Now, no more positive refutation of this notion can be imag than the artificial construction of substances, in every respect. those obtained from the animal and vegetable kingdoms, and some of the philosophical interest attached to the problem which the subject of this discourse.

The first definite example of the construction of an organic from inorganic materials was given by Wöhler, in 1828, when he the organic base urea from cyanate of ammonia.

Let us trace the steps of this process. Cyanide of potassiu body which can exist at a red heat (some cyanide of potassiu exhibited in the form of tabular masses which had been fused), which can moreover be formed directly from its constituents (car nitrogen, and potassium)—was oxydized by means of peroxid ıganese at a low red heat, and so cyanate of potash was obtained. e cyanate of potash was next converted into cyanate of ammonia by ible decomposition with sulphate of ammonia. Thus cyanate of monia was produced from its elements by a process which, although lirect, still did not involve the action of either a plant or an imal. Cyanate of ammonia becomes urea, when its solution in ter is simply evaporated to dryness.

It was curious that the first organic body to be constructed should re been a nitrogenous compound.

In 1831, three years after this important discovery of Wöhler's, nic acid — the first term of the fatty acid series—was obtained from rganic materials by Pelouze. The process was this:—Hydro- ic acid, a body capable of being obtained from inorganic materials, heated either with strong alkalies or acids, and was so made to react n the elements of water as follows:—

$$\overbrace{C\ N\ H}^{\text{Hydrocyanic Acid.}} + 2\ H_2\ O = N\ H_3 + \overbrace{C\ H_2\ O_2}^{\text{Formic Acid.}}$$

yielded formic acid.

It does not appear that this research of Pelouze's attracted that ntion which it deserved. This we must attribute to the circum- ce, that at this period the position of formic acid in the organic es was not recognized.

The next step of importance in organic synthesis was taken by be in 1845. It was the synthesis of acetic acid, the second term the fatty series. Kolbe's process was this:—Sulphide of carbon, ained by the direct combination of carbon with sulphur at a red t, was submitted to the action of chlorine at a red heat, by which ms certain compounds of carbon and chlorine were obtained. One the compounds, $C_2\ Cl_4$, was then acted upon by chlorine in the pre- ce of water, and tri-chlor-acetic acid resulted.

Having thus got tri-chlor-acetic acid by thoroughly inorganic ans, Kolbe availed himself of the observation which had been de of *Melsens* — that treatment of tri-chlor-acetic acid with ium-amalgam and water converted it into acetic acid.

Kolbe was fully sensible of the scope and importance of his overy. The following passage occurs in his paper, published in iebig's Annalen,' for 1845:—"From the foregoing observations deduce the interesting fact that acetic acid, hitherto known as a product of the oxidation of organic materials, can be lt up by almost direct synthesis from its elements. Sulphide of on, chloride of carbon, and chlorine are the agents which, g with water, accomplish the transformation of carbon into acetic . If we could only transform acetic acid into alcohol, and out of latter could obtain sugar and starch, then we should be enabled to d up these common vegetable principles, by the so-called artificial hod, from their most ultimate elements." Thus it appears that be looked forward to the building up of organic bodies in general.

and that he was quite alive to the fact that the synthesis of acetic acid completed the synthesis of the derivations of acetic acid.

Among these derivations may be enumerated acetone, the product of the destructive distillation of acetates; marsh gas, obtained by distilling an acetate with a caustic alkali; ethylene, obtained by Bunsen by heating kakodyl, which itself results by the action of arsenious acid upon an acetate. The electrolysis of acetic acid, which Kolbe accomplished a few years afterwards, yielded methyl and oxide of methyl, which latter, in its turn, could be transformed into any other methylic compound.

Marsh gas was moreover prepared by Regnault, by treating $C Cl_4$ with nascent hydrogen; and the common methylic compounds appear to have been produced by Dumas from marsh gas, the chloride of methyl having been obtained by Dumas by the action of chlorine upon marsh gas.

Before 1854, all the foregoing syntheses were fully completed, *i. e.* there was no step missing between the elements themselves and the most complex compound reached; but, in addition to these complete and definite syntheses, there had also been a good deal of building up of an incomplete or of a less definite character before 1854.

It was known, in a general way, that organic bodies of tolerably simple composition sometimes gave complex products on destructive distillation. Thus, alcohol was known to give naphthaline, benzol, and carbonic acid when it was pressed through a red-hot tube. Formiates were also known to yield hydro-carbons when they were subjected to destructive distillation. The precise dates of these different observations I cannot give, but hand-books of chemistry, published before 1854, contain a statement of the facts.

A few years after 1820—before Wöhler's celebrated Synthesis of Urea, a very remarkable instance of passage from a simpler to a more complex compound was given by Faraday and Hennell. This example is placed along with the indefinite syntheses because it was generally disbelieved in by chemists, and only within the last few years, when it was confirmed by Berthelot, received the general assent. Faraday and Hennell found that olefiant gas was absorbed by sulphuric acid and gave sulpho-vinic acid, from which of course alcohol and the ethers might be procured. Liebig denied what Faraday and Hennell had asserted, and the latter did not insist upon the correctness of their work, and did not take the necessary steps for ensuring the reception of their results.

Shortly before 1854, a most capital addition to the art of organic synthesis was borrowed from the doctrine of the Homologous Series. I will endeavour to explain it.

Organic bodies repeat themselves: thus common alcohol has a whole series of representatives, differing from it in formula by $n(C H_2)$, but resembling it very closely in chemical functions. Alcohol, and these its representatives, constitute a homologous series. Every one of these representatives (homologues) of alcohol possesses a set of ethers and other derivatives, just as common alcohol possesses its ethers and erivatives. With certain limitations, it is true that whatever reaction in be accomplished with one alcohol can be accomplished with any ther alcohol of the series.

Synthesis by series will then be easily understood by an example :— uppose we obtain a building-up by starting with common alcohol, we ould infer that an analogous building-up could be made by starting ith any other alcohol of the series.

Here follows a table of the homologous series of alcohols, and of e homologous acids which are related to them :—

Methyl alcohol	$C\,H_4O$	$C\,H_2O_2$	Formic Acid
Ethyl alc.	C_2H_6O	$C_2H_4O_2$	Acetic A.
Propyl alc.	C_3H_8O	$C_3H_6O_2$	Propionic A.
Tetryl alc.	$C_4H_{10}O$	$C_4H_8O_2$	Butyric A.
Amyl alc.	$C_5H_{12}O$	$C_5H_{10}O_2$	Valerianic A.
Hexyl alc.	$C_6H_{14}O$	$C_6H_{12}O_2$	Caproic A.
,,	,,	,,	,,
Cetyl alc.	$C_{16}H_{34}O$	$C_{16}H_{32}O_2$	Palmitic A.
,,	,,	,,	,,
Ceryl alc.	$C_{27}H_{56}O$	$C_{27}H_{54}O_2$	Cerotic A.

A good example of synthesis by series was furnished by Frankland d Kolbe, who showed that various cyanides of the alcohol-radicles ield the next higher acid in the series when they are digested with an lcoholic solution of potash, thus :—

$$\overset{\text{Cyanide of Methyl.}}{\left.\begin{matrix} C\,H_3C\,N \\ +\ 2\,H_2O \end{matrix}\right\}} = \overset{\text{Acetic Acid.}}{\left\{\begin{matrix} C_2H_4O_2 \\ +\ N\,H_3 \end{matrix}\right.}$$

The effect of the alkali is to cause decomposition of water by means f the cyanide, and the reaction very closely resembles Pelouze's, of hich mention has already been made.

By means of this synthesis, which is general to the whole series, hemists acquired a method of ascending from any given alcohol to e acid belonging to next higher alcohol. It will be evident, however, that this step, important though it was, did not suffice to enable hemists to march regularly up the ladder. The step from acetic cid to alcohol—from an acid to an alcohol of the same carbon-ondensation, was wanting.

This synthesis by series was an incomplete synthesis; there was a ap requiring to be filled up, in order that the regular march might e made up the vinic series.

From the foregoing, it will be seen that by the year 1854 very onsiderable progress had been made in the building-up of organic odies from their ultimate elements.

We now pass on to the consideration of the period comprising the st ten years, from 1854 up to the present time.

During this period we have had new methods of accomplishing ome of the syntheses which had been effected previously. Thus, formic acid, which, as we have seen, had been formed from inorgani materials so long ago as 1831, was built up by Berthelot by means carbonic oxide and caustic potash,—

$$CO + KHO = CHKO_2$$

and again by Kolbe, by using carbonic acid, moisture, and sodiu (the moisture and sodium giving nascent hydrogen),—

$$CO_2 + H + Na = CHNaO_2$$

Again also, the passage from an alcohol to the next higher acid w repeated. Carbonic acid and a compound of an alcohol-radicle wi an alkali-metal coalesced, and formed a salt of a fatty acid thus:—

$$CO_2 + \overbrace{NaC_2H_5}^{\text{Sodium-ethyl.}} = \overbrace{C_3H_5NaO_2}^{\text{Propionate of Soda.}} \quad *$$

Still these reactions, however interesting they might be, were n new syntheses; they were only new methods of effecting old synthes

The great problem, how to step from one alcohol to that ne above it, has received a general solution from Mendius. Mendius us cyanogen compounds, those hydrocyanic ethers which had alrea done such good service to organic synthesis, and exposed them to t action of nascent hydrogen, and so obtained amides of alcohol-radic higher than the alcohol-radicles started from. The reaction bears close similarity to the one which takes place between the cyanides a alcoholic solution of potash, and which, as will be remembered, enabl us to pass from the alcohol to the acid next above.

Here is a scheme to show the parallel:—

TRANSFORMATION TO AMIDE.

$$\overset{\text{iv}}{C}\left\{\begin{matrix} N''' \\ C_2H_5' \end{matrix}\right. \qquad \overset{\text{iv}}{C}\left\{\begin{matrix} NH_2' \\ H \\ H \\ C_2H_5 \end{matrix}\right.$$

TRANSFORMATION TO ACID.

$$\overset{\text{iv}}{C}\left\{\begin{matrix} N''' \\ C_2H_5' \end{matrix}\right. \qquad \overset{\text{iv}}{C}\left\{\begin{matrix} HO \\ O'' \\ C_2H_5' \end{matrix}\right.$$

In the one case nitrogen is replaced by NH_2 and H, H; and in th other by HO' and O''.

---

* The experiment was shown, and the great evolution of heat which t place on bringing carbonic acid into contact with sodium-ethyl was apparent.

Mendius was able to commence even with hydrocyanic acid. The ps in his synthesis are these:—

Hydrocyanic Acid to Methylamine.

$$(1) \qquad CNH + H_4 = CH_3NH_2$$

ethylamine, by means of nitrous acid to methyl-alcohol: methyl-ohol to cyanide of methyl, well-known processes being employed to ect this:

Cyanide of Methyl to Ethylamine.

$$(2) \qquad CNCH_3 + H_4 = C_2H_5NH_2$$

From ethylamine it is easy to get cyanide of ethyl, from which, by hird repetition, we arrive at the propylic stage:—

$$(3) \qquad CNC_2H_5 + H_4 = C_3H_7NH_2$$

Thus the vinic series may be ascended; thus there is reason to think may begin with so simple a body as prussic acid, and step by step ceed from one alcohol to the next above it, until we reach the fats l the waxes. There are other methods of effecting the synthesis of alcohol series, but none of them seem to be so complete and isfactory as this:—Berthelot has obtained alcohols by adding the ments of water to the olefines, and some of the olefines he has ained by the destructive distillation of formiates; but it is an n question—how many olefines can be got by heating the formiates? d, at any rate, there is no precision in the preparation of olefines m formiates.

A very neat and beautiful way of preparing one olefine, *viz.* com-n olefiant gas is, however, due to Berthelot. He exposes charcoal the action of hydrogen at a very high temperature—the temperature the electric arc, and then union takes place, resulting in the formation Acetylene:

$$C_2 + H_2 = C_2H_2$$

etylene exposed to the action of nascent hydrogen in an alkaline uid gives olefiant gas:—

$$C_2H_2 + H_2 = C_2H_4$$

Friedel and Wurtz have converted aldehydes and ketones into ohols by the action of nascent hydrogen, and thence there arises ther method of ascending the vinic series, and besides there are a nber of other reactions which are capable of more or less general ployment for the purpose of building up the alcoholic series, but ich we have not time to particularize.

The alcohols having been got, many other important organic pounds follow, and there is good reason for believing that with the progress of the science all will be derived from them, so the series of the alcohols will constitute a kind of backbone to org chemistry.

Most modern organic researches are capable of being looke from a synthetical aspect, for they generally disclose how to devise organic bodies from compounds which either themselves are, or will capable of complete synthesis. Glycerine, the base of the fats, been derived from the propylic series, having been obtained, by W by a somewhat circuitous process from propylene—the olefine of series.

The sugars have not been, as yet, *unequivocally* produced, but will be, for their connection with the hexylic series is now pl beyond a doubt. The production of glycerides from glycerine fatty acids is the proof that the natural fats are within our grasp. aromatic series with its many derivations, among which may be tioned the wonderful aniline dyes which rival those got more imm ately from the animal and vegetable kingdoms, becomes accessibl synthesis through common alcohol, which on being heated to red gives benzol and carbolic acid—members of the aromatic series.

Wurtz's compound ammonias, and above all, the immense wonderful development of the class of compound ammonias ari from the labours of Hofmann are the pledge that the natural alkaloi quinine, morphine, strychnine, and their congeners will one day within our reach.

Glycocoll, produced by Perkin and Duppa from acetic acid, the bases of the juice of flesh, which have been recently formed Vollhardt and Hofmann, assure us that albumen—that essential i dient of our food—will not elude us.

Why should those medicines and foods which we find in natur the most useful which are possible? Would it not rather be str if they were?

Hereafter, perhaps, medicines as much more potent than quinine quinine is than the extracts of the commonest herb that grows w may be the produce of our laboratories.

[J. A. W.]

WEEKLY EVENING MEETING,

Friday, February 19, 1864.

RY HOLLAND, Bart. M.D. D.C.L. F.R.S. Vice-President,
in the Chair.

W. S. SAVORY, Esq. F.R.S.

aming and Somnambulism, in relation to the Functions of certain Nerve-centres.

rst portion of the discourse a sketch was given of the general
onstruction of the nervous system, from the simplest to the
plex forms. Then the different kinds of reflex action were
o, and the several centres indicated which, with greater or less
, are known to be concerned in their production. Thus the
and most universal form of reflex action, called excito-motor,
ot necessarily attended by sensation or consciousness, was
to the spinal cord and medulla oblongata. Sensori-motor
those which involve sensation or consciousness, but which do
sarily arouse ideas, were referred to certain ganglia beyond,
the optic thalami—the corpora striata being perhaps concerned
n—and the olfactory, optic, auditory, and gustatory ganglia;
all probability collectively constituting what is called the sen-
each kind of sensation being produced through its own proper
. Lastly, those acts which involve ideas, and which are there-
ed ideo-motor, were referred to the cerebrum.

production of what are called subjective sensations was
d for by the fact, that if an impression be made upon any part
itive nerve, even if in the centre to which it passes, the sen-
perceiving that impression, refers it not to the part of the
hich is impressed, but to its periphery, to the part to which
ents are distributed.

sleep was described as a state of rest of the sensorium and
lobes. Its leading phenomena are the result of the suspension
functions—the suspension of consciousness and of the mental
generally. Sleep is to the brain what rest is to every organ
dy.

reaming it was said,

n sleep is partial or imperfect the functions of those ganglia,
st is sleep, will not be entirely suspended. They will remain,
measure, active. Impressions will still be recognized by the
hemispheres, and will give rise to ideas. Thus dreams are

produced. Dreams, therefore, are the result of imperfect exercise of the hemispheres when in a state of partial repose. There may be total absence of consciousness of external things, and yet withal a state of mental activity, varying greatly in degree and duration.

Dreams then occur when sleep is not profound. They cannot arise during complete repose.

There is no sufficient reason to deny the existence of a period of complete unconsciousness, of complete suspension of the mental faculties. Doubtless the brain, like other organs, is at times in absolute repose. While dreaming, sleep must be considered imperfect.

Again, if the general view here expressed be the correct one, that dreaming is the natural condition of imperfect repose, there is no good reason for denying the supervention of dreams at any period of sleep.

There can be little doubt that dreams are very transient: but the evidence of the extreme rapidity which has been assigned to all of them is defective. Of course the duration of dreams bears no comparison to that of the events and circumstances which they picture; but looking at the relation of dreaming to somnambulism, their frequent concurrence, the period occupied by day-dreams, and the time that disturbed sleep and other indications of dreaming will sometimes last, it is perhaps more reasonable to conclude that some dreams are not so instantaneous as many imagine.

It is highly probable that all animals with cerebral hemispheres dream. This conclusion, which naturally follows on the view here taken of the nature of dreams, is confirmed by observation.

When impressions reach the cerebral hemispheres they arouse ideas. Impressions may be objective, arising from without, what we call real; or subjective, arising from within, what we call fancies. The exciting cause of dreams then may come from without or from within.

As the chief feature of sleep is a state of unconsciousness, so in general the remarkable feature of dreaming appears to be an absence of the power of will over the current of thought and over action. Thus ideas are aroused in rapid succession without guidance or correction, but no volitional acts are accomplished. Hence the frequent incoherence and inconsistency of dreams. Of course there are all degrees of this. Dreams may be and often are consistent and rational, whether from the more complete exercise of the cerebral lobes or from the nature of the impressions which excite them; but oftentimes they are characterized by a strange want of regulation and co-ordination of the ideas which represent them. When, therefore, we dream what we call nonsense, it is because there is a partial or complete absence of voluntary control over the current of thought, and because we cannot compare our conceptions and ideas with surrounding objects and circumstances and thus correct them.

The extent to which the ideas that constitute dreams are coherent depends probably in great measure upon whether they are habitual or strange to the waking state. When the will is not alert old ideas are more apt to be orderly than new ones, for the former may fall into their accustomed sequence, whereas the latter have not even habit to arrange them. Everyone knows, for instance, how an idea excited by an impression may forthwith arouse a train of others which have been before associated with it. Thus for the most part dreams are rational in proportion as they arise out of existing circumstances.

In comparing then the condition of the mind in dreaming with its active state while awake, we are led to notice these distinguishing features:—

The will is in abeyance. It ceases to control, or rather to direct, the current of thought.

The correcting influence of external impressions is suspended.

Impressions conveyed to the brain, when awake, excite ideas which are, for the most part, in a healthy mind, subjected to the regulating influence of the will; and if they give rise to acts, these are voluntary and rational. But when the influence of the will is suspended, and it ceases to direct the current of thought, the acts which such ideas thus produced may at once excite are often strikingly irrational or altogether absurd. Such examples may be seen in persons intoxicated by alcohol, chloroform. or laughing gas.

As in these cases, so, and in the same way, it is doubtless possible sometimes to lead the ideas during sleep, when not profound, by means of external impressions, and even to determine their nature. Thus gloomy ideas may be suggested by a dull tone of the voice, while cheerful ones may be aroused by lively sounds. In the same way the ideas may be adapted to certain conditions in which a person may be placed. Every work on the subject contains some illustrations of this.

And just as a dream may be started by an external impression, so an impression made upon any of the senses during a dream will oftentimes fall into the current of ideas then flowing through the mind. Thus a noise may become the report of fire-arms, or the shout of a multitude, or a peal of bells, or something else, according to the subject of the dream.

The nature of dreams in their relation to the absence of the correcting influence of surrounding circumstances is well illustrated by the effect of darkness and silence on delirium. The phantoms which then arise, the correcting influence of external circumstances being shut out, will often at once disappear in the presence of light, or at the sound of a well-known voice.

There is a peculiar condition of the mind often occurring in some persons which is well expressed by the phrase, day-dreaming. In this state the ideas are allowed to flow on without control. They are not restrained by any effort of the will. In the worst form they are not even co-ordinated. One idea suggests another, and so on, until the thoughts have wandered far away from the original subject. Nothing is seen but the visions of fancy. The most improbable, nay, impossible, prospects are conjured up and contemplated either as present or future realities, and no attempt is made to check or control the most extravagant or erroneous conclusions. Here, however, at least at the outset, there is an indisposition rather than an inability to reason.

When in this state, a person is said to build castles in the air. The mind is wholly withdrawn from the consideration of external and surrounding circumstances, and revels in the luxuriance of its thoughts. This is really a dreaming state, although, owing to the activity of the sensorium, day-dreams are more readily corrected by external circumstances.

Indeed, if we attend at all to the state of our mind, we must observe that it varies widely, and during a considerable portion of our waking hours, in many persons, especially in the young, its condition is not far removed from that of day-dreaming. When we are not at work, when the attention is not fixed, during periods of leisure, the intellect is wont to escape insensibly from the control and direction of the will, and to wander far on into the regions of thought, one idea suggesting another, which forthwith takes its place. One step further, and the influence of surrounding circumstances is almost shut out, and the imagination revels without restraint. Then we may be said to dream.

Day-dreaming or reverie, and the dreams of sleep, are connected by a peculiar phase of dreaming, which sometimes occurs when the sleep is unusually light, or more often when we are awakening out of sleep. In this state the sensorium is more or less active. We are conscious. It is characterized, moreover, by a partial and imperfect control over the current of thought, and a voluntary effort, in some degree successful, is made to prolong agreeable ideas, and to dispel gloomy ones. This condition must be familiar to everyone as occurring at the dawn of day, before rising.

Again, everyone knows that a dream out of which we have awakened is very liable to recur if we soon fall asleep again. Such cases tend to establish the relation between our sleeping and waking thoughts. By watching and analyzing the phenomena, we can observe how insensibly they pass into each other, the vision of our sleep rising into ascendancy as the influence of external impressions and of the will is withdrawn.

Of Somnambulism.

Now, just as dreams may be regarded as due to partial activity of the cerebral lobes when in a state of imperfect repose, so may the condition termed Somnambulism be regarded as essentially the result of a state of more or less complete activity of the sensorium, the hemispheres beyond being nevertheless at rest.

In what may be called the purest form of somnambulism various acts may be accomplished in the most perfect manner, as the direct result of impressions, without any evidence of the intervention of ideas.

But although in somnambulism impressions do not necessarily arouse ideas, yet they nevertheless produce sensations and determine sensori-motor acts. That they reach the sensorium and are not merely

cito-motor in their nature, is evident from their results. Sounds are
metimes heard and objects recognized by the sight and touch.

The term somnambulism appears to be very loosely employed. In
most common acceptation a combination of dreaming and som-
mbulism is implied. Perhaps, indeed, this is the most common
rm of somnambulism. Not only is the sensorium active, but the
mispheres themselves are partially awake. But although the descrip-
on usually given of somnambulism would imply an active state of
e cerebral hemispheres as well as of the sensorium, would include a
ate which is essentially that of dreaming—so that somnambulism is
scribed as an "acted dream"—yet while admitting that this more
mplicated condition may be a common one, it is in the highest degree
nportant to recognize the fact, that a state may occur in which some
r all of the sensorial centres are active, the cerebrum itself being
evertheless in a state of complete repose, the actions which result
eing simply sensori-motor, or instinctive ones. Thus no ideas are
roused, and nothing is remembered. This may be described as the
implest and purest form of somnambulism.

It seems, then, that the clearest and most correct idea will be
btained of these two states, and of their relation to each other, by
egarding them as manifestations of various degrees of activity of those
entres which in profound sleep pass into a state of complete repose:
hat either alone may be active while the other is at rest, or both together
n imperfect sleep, may exhibit all degrees of partial activity in various
roportion, short of that thorough and complete exercise of their
unctions when wide awake.

It appears that this view will afford an insight into certain facts
which do not otherwise admit of explanation.

Dreaming is more frequent than somnambulism, because of all
ortions of the nervous system the cerebral lobes are the most sensitive
o variations in the quantity and quality of blood circulating through
hem. Witness the effects of alcohol, ether, and chloroform.

Somnambulism is more common in the young, because then the
ensorial centres are more prone to activity. With regard to dreams,
he rule is less general, being influenced by habits of mental exercise.

The remembrance of dreams, not of somnambulistic acts. It is
mportant to note the absence of memory in somnambulism. It
ppears that acts purely somnambulistic are never remembered or
ecalled. This seems to point to their nature. They find their parallel
n instinctive actions.

The dexterity and accuracy of somnambulistic acts, for example,
of muscular movements in walking. Perhaps, in this case, the cere-
bellum is awake also.

The somnambulist walks across a narrow plank, over a frightful
hasm, steadily, and without fear. Why? Because the act is a sensori-
motor one, and no idea is called into play. For the same reason a
erson wide awake may accomplish the same feat in the same manner,
f the danger be concealed from him, if he have no idea of it. In

the former case he may see it, but has no idea of it. In the latter he has no idea of it because he cannot see it.

In this view of the matter, therefore, the actions of the somnambulist are essentially of the nature of instinctive ones. A careful analysis of them will show that they possess this character. In the simplest and purest form of somnambulism as in the simplest and purest examples of instinctive acts, there is not any satisfactory evidence of the operation of the intellectual powers. In either case is seen the adaptation of means to ends, but there is no evidence of the intervention of ideas, of the calculation of consequences, of reason. This difference, however, must be noted in the two cases. The operations of instinct are invariably associated with an active and acute state of the senses. In somnambulism all the senses are not commonly in full activity.

Summarily, then, these several states may be thus contrasted:—

In profound sleep there are no acts beyond excito-motor ones, and even these are reduced.

In somnambulism there are, beyond these, sensori-motor acts.

In dreaming, ideas are aroused.

Dreaming, or a combination of the two, must be distinguished from purely somnambulistic acts. Perhaps in the most common form of somnambulism dreaming is, to a greater or less extent, combined with it. Thus somnambulism is presented under various forms, according to the absolute and relative degree of activity of the different senses, and the condition of the cerebral lobes. All forms occur from merely turning in sleep, to walking, talking, writing, and so forth.

And as in somnambulism some degree of activity of the cerebral lobes may be associated with an active state of the sensorium, so in dreaming some degree of activity of the sensorium may be combined with an active state of the cerebral lobes.

In those cases of so-called somnambulism, in which acts are performed which involve a considerable exercise of the mental powers, the simply somnambulistic state must be combined with vivid dreaming. In this combination so many of the faculties are more or less active, so few, if any, completely at rest, that the individual is more awake than asleep.

[W. S. S.]

WEEKLY EVENING MEETING,

Friday, February 26, 1864.

Sir Roderick I. Murchison, K.C.B. D.C.L. F.R.S. Vice-President, in the Chair.

Joseph Prestwich, Esq. F.R.S.

On the Quaternary Flint Implements of Abbeville, Amiens, Hoxne, &c., their Geological Position and History.

Mr. Prestwich remarked upon the imputation of rashness, and even of credulity, which discoveries such as that of the flint implements often entailed upon geologists. He contended that geologists were, on the contrary, generally disposed to be incredulous. At one time they believed that Fishes were no older than the Carboniferous strata; that Reptiles first appeared during the Liassic period; and that Mammalia could not be traced beyond the Tertiary strata; and it was a long time before they were satisfied that Fishes go back to the Silurian, Reptiles to the Carboniferous,* and Mammalia to the Triassic period. And so with Man. Ten years ago there was scarcely a geologist in this country who would not have deemed the occurrence of the works of man in any beds older than the recent Alluvium impossible. The discoveries made by Tournal and Christol in the south of France, thirty years since, of the remains of man associated with those of extinct mammalia, were rejected by geologists unanimously; nor were the analogous discoveries of Schmerling in Belgium more favourably received; whilst Frere's remarkable notice, so far back as 1797, of the discovery, at Hoxne, in Suffolk, of flint weapons mixed up with the bones of large extinct animals, was allowed to lie dormant for sixty years.

Even so late as 1855, a communication by the Torquay Natural History Society, respecting the occurrence of worked flints with the fossil bones in Kent's Cave,—a fact already, years before, noticed by the Rev. Mr. M'Enery and by Mr. Godwin-Austen,—was deemed, by the Geological Society, too improbable for publication.

Mr. Prestwich doubted whether, prior to 1858 and 1859, there were twenty men of science in Europe who would have admitted the possibility of the contemporaneity of man and of the extinct mammalia. He instanced Dr. Grant as one of the small number who, on abstract principles, treated the question as an open one. He also noticed the tone of confident disbelief with which the asserted occurrence of flint implements in certain geological deposits in the Somme valley was spoken of when he made inquiries respecting this subject in Paris in 1856 and 1857, and which for a time turned him from the inquiry. Such instances might be multiplied. The speaker did not bring them forward as indicating any perverse opposition, but to show how reluctant geologists were to abandon the belief generally held on this subject without the clearest proofs, and close and careful search on their part. Such, he remarked, is the inevitable progress of all discovery. Facts deemed contradictory to received theory are often long rejected, some as clearly failing in proof, others as non-proven. Evidence is hesitatingly received, and has to force its way through a resisting stratum of incredulity; but, as in the searching resistance offered by close tissues in the separation of mercury from its dross, that portion which passes through issues the brighter and purer the more difficult the transit, and the stronger the pressure exercised.

---

* Possibly to the Old Red Sandstone.

Allusion was then made to the distinguished palæontologist, Dr. Falconer—one man of science at least in this country with whom the conviction that the remains of man might be traced back to periods greatly antecedent to our ordinary records, had grown, during a long course of years, from probabilities suggested by Eastern research, into certainty established by extensive investigation among the European fossil-bone caves. Referring to his late exploration of Brixham Cave in 1858, the attention which the well-certified discovery of flint implements in undoubted association with the remains of extinct mammalia and of reindeer attracted amongst geologists was remarked upon. The speaker visited the cave in company with Mr. Pengelly, and was much struck with the force of the evidence, though, for various reasons, he considered that cave evidence alone was not sufficient. Urged by Dr. Falconer to go and examine the geological evidence respecting the flint implements in the valley of the Somme, he afterwards paid his long-intended visit to Abbeville (where he, on the very first day, was fortunate enough to find three worked flints at Menchecourt) He was joined, on the next day, at Amiens, by his friend Mr. John Evans. The geological evidence, and the character of the Flint Implements, satisfied them both that here again was an undoubted case of contemporaneity of the works of man with the remains of the extinct Mammalia. All the author has since seen on many subsequent visits to the Somme valley, sometimes alone, but more frequently in company with other geologists, has tended to confirm his first opinion. He then proceeded to notice some of the phenomena he had seen, and to give his conclusions respecting them. He had intended to have described the several localities in France and England at which flint implements had been found, but found that time would not allow his going beyond Amiens. This was the less important, as Mr. Lubbock had so recently given an able account in the same room of most of these places; and his auditors were probably most of them acquainted with the more general account given by Sir Charles Lyell in his recent work on the 'Antiquity of Man.'

Mr. Prestwich then went on to describe the remarkable discovery of M. Boucher de Perthes, and how much honour and credit were due to him for his untiring perseverance, in face of general discouragement, for a period of twenty years, and for twelve years after the publication of his elaborate work, 'Antiquités Celtiques et Antédiluviennes.' Incited by this work, Dr. Rigollot, an antiquary of Amiens, discovered Flint Implements in great numbers near that town; but his careful memoir on the subject, although it attracted the momentary attention of some French geologists, was allowed to drop comparatively unnoticed. Geologists admitted the antiquity of the beds, and antiquaries admitted the workmanship of the implements; but neither would own to a conjoint interest and belief in them.

Before entering upon the details of the sections, Mr. Prestwich proceeded to make a few remarks upon the conditions under which the flint-implement-bearing beds were found, and how their importance and the time they represent were to be judged of. He observed that sea-formed deposits afforded massive and tangible monuments of the length of time required for their accumulation. But on land, time passes, and builds no such monuments of its duration. The sand and shingle beds of a rapid river would be little, if at all, thicker now than a thousand years ago, for, instead of accumulating in the channel of that river, they are incessantly removed, and carried eventually out to sea, where they contribute to the formation of the great sedimentary deposits constantly going on there. The time represented by river deposits (apart from the recent silty alluvia) is not therefore to be measured by their thickness; and we must not attach the less importance to the beds containing the Flint Implements, because, being formed by river action, they are necessarily small, fragmentary, and superficial. But while in the sea the accumulation of matter has formed a relative measure of time, on land the extent of denudation resulting from the removal of a portion of that matter supplies an obverse scale. In the former case the lapse of time is chronicled by constantly accruing deposits, whereas in the latter case the deposits cannot exceed a certain thickness. They are constant quantities, and their dimensions are no measure of their age. The only test of their age consists in their organic remains, and in the depth of the valleys below the terraces on which portions of them are lodged. In speaking of river action, the author does not refer to the slow and sluggish streams of this country, but to the more active streams of countries of greater rainfall, or to old conditions of former periods.

Mr. Prestwich then proceeded to refer to a large pictorial section of the celebrated pit at St. Acheul, near Amiens. The artist had not visited Amiens, but had skilfully contrived to give a sufficiently accurate representation of the town and valley, for the purpose of showing the general relation which the ground there bore to the surrounding district. The details of the pit were, however, all given from actual survey by the speaker. The surface of the ground at the pit is 100 feet above the level of the Somme, which flows in the valley at the foot of the hill. The valley itself is about one mile broad. The hills on either side, rising to a height of 200 to 300 feet, consist of chalk, with a few and distant cappings of tertiary strata.

On platforms of various breadths, generally on the top of low hills adjoining the valley, patches of gravel occur at intervals more or less long from the lower to the upper end of the valley, whilst a more connected series of gravel beds skirts the base of the valley. The chief portion of the valley is, however, occupied by alluvial beds, beneath which the last-mentioned gravels with their brick-earth, pass.

The higher level gravels rarely contain organic remains. The pit at St. Acheul affords a singularly good example of these beds, and is unusually rich in organic remains, and also in flint implements.

The section exhibits :—

	Feet
1. Brick-earth (Loess) without organic remains . .	10 to 15
2. A variable bed of whitish, marly sand, with numerous *freshwater* and *land shells* of recent species, and a few *mammalian remains*	3 to 7
3. Variable beds of subangular flint gravel—some white, others ochreous and ferruginous. Numerous *fossil bones* and *flint implements*, and a few *shells* as above, irregularly dispersed throughout .	5 to 14

These beds repose upon a base of chalk. The site having been long occupied as a Gallo-Roman cemetery, the upper brick-earth is intersected with pits and graves—in some there are stone, or rather hard chalk, coffins, whilst in others the nails and iron-work alone remain, the wood having entirely decayed away. These portions of disturbed ground are easily recognized by their darker colour, their contents, but more especially by the break they produce in the stratification of the beds. So long as the ground is undisturbed the lines of the brick-earth, the lamination of the sands, and the rough bedding of the gravel are continued in horizontal planes without break. Any interference from above breaks these lines and mixes the different beds, and renders the disturbance at once apparent. In the absence of any such indications it is to be assumed the fossils and the flint implements are in undisturbed ground.

The Flint Implements are found scattered irregularly through the gravel, but they are more numerous in the lower part. It has been estimated that there is one implement to one cubic yard of gravel. They occur singly, and as far as we know, lying flat. The spot where one was found *in situ* by Mr. Flower was pointed out in the section, and also the spot where the speaker and Mr. Evans extracted one. These worked flints partake of all the mineral characters of the gravel—the result of contemporaneous deposition. Some retain their original dark colour, others are stained yellow and brown—some have their outer surface converted to a bright white—many are incrusted with thin patches of carbonate of lime—and many again exhibit dendritic markings

—all being conditions in perfect harmony with the mass of broken subangular flints composing the body of the gravel, of which they are, in fact, component parts, showing one and the other like characters of age. Several hundred specimens of flint implements from this pit have passed under the speaker's inspection; thirty selected specimens were exhibited, showing the principal forms which prevailed, and in which the workmanship and design were most apparent. Few can feel any doubt who inspect a series of this nature. It is not so much evidence of art and skill that we look for, but primarily of design. The speaker did not dwell on this point, which is now generally accepted. It has been well treated by Mr. Evans and others.

The fossils consist of perfect and uninjured, though very friable, land and fresh-water shells in the following proportion, and of bones, mostly broken, and teeth of the following animals. The list is necessarily only a sketch.

FAUNA OF THE QUATERNARY GRAVELS OF THE SOMME VALLEY.

	ANIMALS.	SHELLS.
Extinct species.	Elephas primigenus.	14 species of land shells.
	——— antiquus.	
	Rhinoceros tichorhinus.	9 species of marine shells (Abbeville only).
	Hippopotamus.	
	Ursus spelæus.	
	Hyæna spelæa.	21 species of freshwater shells.
	Felis.	
Some extinct, some living.	Cervus (2 or more species).	All these are of species living in France, and all but one in England, except the Cyrena fluminalis, now living in the Nile and Central Asia.
	Bos (2 or more species).	
	Equus (2 species).	

Proceeding to interrogate the section with a view to determine the causes which led to the formation of these beds, the nature of the climate which then prevailed and their age, the following conclusions were deduced:—

1. The mineral ingredients of the gravel are chiefly broken flints derived from the chalk of the district in general, but with these there occur fragments and blocks of tertiary sandstone and tertiary fossils, which could only have come from places 10 to 20 miles higher up the valley. Therefore the agency, whatever it was, that brought the débris here must have proceeded in a direction down the present valley, the tertiary débris being found along that line as far as the sea. Further, the cause could not have been a general one extending beyond the present hydrographical basin, for none of the older rock débris from the valley of the Oise, which is only separated by a water-shed six miles broad from that of the Somme, passes from it into the latter valley.

2. The presence of freshwater shells in some of the intercalated beds, many such as live in clear and rapid streams, indicate a probable fluviatile origin for these deposits.

3. The mammalian remains and land shells give evidence of dry land. The occasional occurrence of bones in the position they held during life show that the carcases and limbs of animals were dropped into the old shingle before they were freed from their integuments, or within a short time after death—whilst the perfect state of preservation of the land shells is an indication of their not having been transported far.

All these characters tend to prove that these beds are to be referred to old river action. This, however, must have taken place when the river occupied a level about 100 feet higher than it does now. It is true that similar gravels, containing similar mammalian remains and also flint implements, occur at lower levels (40 feet) in the valley, whence it is inferred that similar causes were in operation when these also were deposited. But it is plain that the two could not have been deposited at the same time. For the deposition of the high-level gravels on the supposition that the valley had been previously excavated, would have required a river at some times filling a channel more than a mile wide, and 100 feet deep—a state of things not to be accounted for under any circumstances. The alternative therefore of a river flowing at the higher level and gradually excavating its channel is adopted.

The character of the climate may be inferred from the fauna. The land and freshwater shells are of species now living in France, but they also range as far north as Russia, Finland, and Siberia. They are therefore such as, though occurring in temperate climates, are capable of existing in high northern latitudes. The animal remains furnish more positive testimony. The woolly Mammoth and Rhinoceros were fitted by their coating to endure the rigours of a cold climate, such as Russia and Siberia, where their remains abound, and where they seem to have fed on the vegetation common to such latitudes. A species of Tiger now lives in Central Asia, and is often tracked and hunted down in the winter on the snow and frozen lakes of that region. The Reindeer, of which we have the remains in the valley of the Somme, and the Musk Ox, which occurs in the same deposits in the valley of the Thames, indicate still more clearly the northern tendencies of this group. There is a difficulty about the Hippopotamus, but the elephant and rhinoceros originally presented the same difficulty; and there seems no reason why in this case also the extinct species should not be found to have been fitted to live in a severe climate.

These conclusions are corroborated by the physical phenomena. Mr. Prestwich pointed on the large section to numerous blocks of sandstone but little worn, and varying in weight from ½ to 5 tons, which could hardly have been carried and deposited, as now found, by water alone. He also showed various contortions in the upper beds of gravel (whilst the lower ones were hardly disturbed), and in the laminated sands overlying them. These he attributed to ice-action. The blocks, to transport from places higher up the valley on ice-floes at the breaking up of the ice in the spring, and the contortions to the grounding of ice-the soft sand and loose gravel, impinging into them and piling gravel, as now occurs on the banks of some of the Canadian He pointed especially to the pendant masses of brick-earth in the upper part of the sands, and which he attributed to masses of ice brought down in flood time, grounding on the rth and pushing a portion of it into the underlying beds of here, as the ice gradually melted, it would be left, caught, and d in by the sand pressing itself into place again.

two classes of evidence are, therefore, conformable. It is in y also with the existence of the large beds of brick-earth or verlying the gravel, and which is doubtlessly the deposit of the r during floods, usual in a severe climate at the time of the of the winter snows. The winter climate may probably have rigorous as that of Northern Russia or Northern Canada. climate would not be any bar to the presence of man, whose re found in these old shingle beds. It is true that none of his have yet been found in these deposits, but they are found in f the same age. The abundance of animal remains is the almost le consequence of a country subject to great river floods, by arge numbers of animals are always destroyed and swept down; the contrary, guards against such risks. Along the Northern an rivers of the present day, although the remains of the buffalo er animals occur in profusion, the remains of man are scarcely t with. There is every reason to expect that this further and le proof may be forthcoming at no long distance of time.

tly, the speaker stated that the present river Somme only down fine silt and mud, whereas the old river transported asses of coarse shingle; therefore, it is to be inferred that the er was one of much greater power than the present one. floods especially, its power must have been very great; with transporting power the river would possess greater excavating at the same time the disintegration of rocks, especially such ks as the chalk of this district, produced by severe cold, com-with the effects of ground ice lifting up from the bed of the rge quantities of the shingle, would hasten the deepening of the As it deepened, terraces of shingle have been left at places slopes. It may be difficult to imagine a river with so limited a ng ground filling a valley a mile wide, but this the speaker s to have been the case only during floods, and that the ordinary of the river was very much smaller. He instanced a case in here Dr. Hooker mentions a river which was only 80 yards wide e crossed it, but which after the rains covered a channel 3 miles nd ran 10 to 12 feet deep. The melting of the snow in the produces the same result in arctic regions as heavy and con-rains in southern regions.

Prestwich next exhibited a diagram to show what he con-to be the different phases of the phenomena, from the period e beds of St. Acheul were formed, until the valley assumed its present form and dimensions. The plan, which was formed of a series of superimposed sections, showed—

1. *The old river during the deposition of the shingle and sand banks of St. Acheul.*—In this the bed of the river was occupied with large shingle banks, which were left dry during the time the river was low. Mr. Prestwich supposes these to have been resorted to by early man, in consequence of the number of large flints they contained, for making flint implements on the spot. This may be one of the reasons why they are so numerous at St. Acheul, which was shown to be one of those old shingle banks preserved from that time. Ice-floes dropped large blocks of sandstone into the shingle. A space shut off in part by a shingle bank would account for the more tranquil accumulation of the middle sand beds of St. Acheul, and for the more numerous shells living there undisturbed. During floods the river rose probably to a height of 20 to 30 feet above its ordinary level, as shown by the brick-earth (without gravel) deposited higher up the hill on the road to Cagny. The next stage showed—

2. *The gravel beds of St. Acheul after they were left dry, except during floods.*—Here the valley had been excavated to several feet below the level of the St. Acheul beds, but during floods the river still extended over them and deposited the brick-earth. Ice-floes grounded and indented the upper beds of sand and gravel, causing contortion of the strata.

3. *The river at the time of the formation of the low-level gravel beds of St. Roch and Amiens.*—The valley had now deepened to the extent of 50 to 60 feet below the level of St. Acheul, and the low-level gravels of St. Roch were deposited under similar conditions, only that ice-action is not so strongly marked. It is in these beds that the remains of the *Hippopotamus* first appear. The flint implements found in them are of a somewhat different type to those of the higher level gravels. The flake form is more prevalent.

4. *The low-level gravel of St. Roch, left dry except during floods.*—Here we have a repetition of the same state of things as found at St. Acheul; the shingle being covered up during floods by brick-earth or loess.

5. *The valley at the present period.*—The progress of excavation shows the valley deepened to its full extent. The river has lost its old power, its flood waters now rising only 2 to 3 feet, and its channel being restricted within a very narrow compass. The old and rough channel left at the end of the Quaternary period is covered to the depth of 10 to 20 feet by fine alluvial soil and peat. All the great pachyderms have become extinct, but the reindeer, bison, and great fossil ox survived during part of the more modern time. Almost all the small and fragile land and freshwater shells have continued in uninterrupted descent to the present day. This fact seems almost conclusive against any general cataclysm having passed over the surface. This concordance between the physical features and the contemporary life, and the capability the hypothesis here offered gives of explaining

ich and every one of the phenomena, affords strong presumptive proof f its truth.

Before concluding, Mr. Prestwich observed that he might be ex- ected to say a few words respecting the age of the Flint Implements. 'wo questions were involved in this: One, the length of time elapsed nce the close of the period of the extinct mammalia; the other, how ır back into that period the flint implements can be traced. In the escription of the sections, it had been previously pointed out, that the uaternary period could probably be brought down immediately to the me when our valleys began their modern accumulation of silt and eat. The period of time, therefore, first to be measured, is that which as been required for the formation of these latter deposits. On this oint there is considerable difference of opinion amongst geologists. he occasion did not afford time to enter into the details of the question, nd the speaker therefore contented himself with an expression of pinion offered with reserve. He considered that more time and better ata were required to make a sure estimate; nevertheless, he was atisfied that the evidence, as it exists, does not warrant the extreme ngth of time so frequently supposed.—The recent alluvia covering e latest quaternary deposits of our valleys are rarely more than 40 et thick,—in most cases not more than 20 feet. The rate of accu- ulation, though it may often be slow, is very variable. A Roman road the valley of the Lea was found covered by 2 feet only of alluvium. nother such road in Cambridgeshire was covered with 5 feet of lluvium. The entire depth of the alluvium was not, however, ascer- ined in either case. M. Rozet gives another instance of a Roman road, hich he considers to have been kept in repair until about the eighth cen- ry, traversing the valley of the Dheune. Its paved and even surface is ow covered by 12½ inches of alluvial soil. A little lower down the valley, is alluvium, which is very uniform, has been ascertained to be about 3 feet thick. This he estimates would have required for its accumu- tion about 10,000 years. The alluvial soil reposes there immediately n the so-called diluvium. The rapidity with which the alluvial soil ill accumulate under favourable conditions is often very much greater. n places, thick beds of alluvium and of peat have been formed since e Roman occupation. Looking at these facts, and at the general ct, that, as a rule, in the valleys of the Somme and of the Thames for xample, the Roman, British, or Gaulish remains are found at a depth om the surface bearing a considerable proportion to the entire thick- ess of the alluvium, the probability is, that the commencement of the lluvial deposits is not to be carried back indefinitely.

One reason for believing the accumulation of the silty alluvium of ur valleys to have been more rapid at one time than now, is that these alleys, left rude and rugged at the end of the Quaternary period, would e subject to more frequent floods until their inequalities were filled up d levelled. Mr. Prestwich concluded by observing that—"For these d various other reasons I am confirmed in the opinion I expressed in 359, that the evidence, as it stood, seemed to me as much to necessitate the bringing forward of the extinct animals towards our own time, as the carrying back of man in geological time. In making that observation I had chiefly in view the distance of time at which the last of the great extinct mammalia disappeared. If there should have been, between the modern valley alluvia and the latest quaternary beds, some intervening period of time of which we are ignorant, that distance may be materially prolonged. If, on the contrary, they followed in immediate succession, and I think we have evidence that such was the case, for there seems reason to believe that some of the large pachyderms still existed at the commencement of the alluvial period, whilst we know that many of the ruminants lived on uninterruptedly from one period to the other, I do not, for my part, see any geological reasons why the great extinct mammalia should not have lived down to comparatively recent times, possibly not further back than 8,000 to 10,000 years.

"But this only brings us to the threshold of that dim and mysterious antiquity in which first appear those rudely-wrought flints,—those evident works of design—those palpable shadowings of man. Here our chronology fails us altogether. If we look at our broad and long valleys, and then at the comparatively small streams now winding through them, and suppose these streams to have been the same in past times as they now are, we could hardly avoid the conclusion that the time required to produce such excavations with such means must be almost incalculable. But if the view here proposed be correct, it would follow that with rivers so large in proportion to those now occupying the same valleys, with floods of a force now unknown in the same districts, with a cold so severe as to shatter the rocks, and to hasten the removal of their débris, we should have, I contend, agencies in operation so far exceeding in power any now acting in these countries, that it is impossible to apply the same rules to the two periods. The changes described must have progressed with a rapidity of which we, at the present day, can in these latitudes hardly form an adequate conception.

"But although I would shorten the Quaternary period by the extent of the differences here alluded to, it still remains of great length and importance, stretching back into a far remote antiquity, and it is far into this period that we have traced these works of man. Although at present we are without a scale or measure to determine that antiquity, we need not abandon the hope, that, by continued and careful observation, we may eventually succeed in forming some comparative estimate of it. The first men who, after traversing the plains of Lombardy, approached the Alps, could scarcely have failed to realize their vast dimensions, although without the means to determine their exact height; so we, from the relative magnitude of the phenomena and the variation of life, can sufficiently well realize the remoteness of the time in question, although we do not yet possess the data whereby to measure its duration, and determine its exact distance from our own time."

[J. P.]

WEEKLY EVENING MEETING,

Friday, March 4, 1864.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

PROFESSOR G. G. STOKES, M.A. D.C.L. SEC. R.S.

On the Discrimination of Organic Bodies by their Optical Properties.

THE chemist who deals with the chemistry of inorganic substances has ordinarily under his hands bodies endowed with very definite reactions, and possessing great stability, so as to permit of the employment of energetic reagents. Accordingly he may afford to dispense with the aids supplied by the optical properties of bodies, though even to him they might be of material assistance. The properties alluded to are such as can be applied to the scrutiny of organic substances; and therefore the examination of the bright lines in flames and incandescent vapours is not considered. This application of optical observation, though not new in principle (for it was clearly enunciated by Mr. Fox Talbot more than thirty years ago), was hardly followed out in relation to chemistry, and remained almost unknown to chemists until the publication of the researches of Professors Bunsen and Kirchhoff, in consequence of which it has now become universal.

But while the chemist who attends to inorganic compounds may confine himself without much loss to the generally-recognized modes of research, it is to his cost that the organic chemist, especially one who occupies himself with proximate analysis, neglects the immense assistance which in many cases would be afforded him by optical examination of the substances under his hands. It is true that the method is of limited application, for a great number of substances possess no marked optical characters; but when such substances do present themselves, their optical characters afford facilities for their chemical study of which chemists generally have at present little conception.

Two distinct objects may be had in view in seeking for such information as optics can supply relative to the characters of a chemical substance. Among the vast number of substances which chemists have now succeeded in isolating or preparing, and which in many cases have been but little studied, it often becomes a question whether two substances, obtained in different ways, are or are not identical. In such cases an optical comparison of the bodies will either add to the evidence of their identity, the force of the additional evidence being greater or less according as their optical characters are more or less marked, or will establish a difference between substances which might otherwise erroneously have been supposed to be identical.

The second object is that of enabling us to follow a particular substance through mixtures containing it, and thereby to determine its principal reactions before it has been isolated, or even when there is small hope of being able to isolate it; and to demonstrate the existence of a common proximate element in mixtures obtained from two different sources. Under this head should be classed the detection of mixtures in what were supposed to be solutions of single substances.*

Setting aside the labour of quantitative determinations carried out by well-recognized methods, the second object is that the attainment of which is by far the more difficult. It involves the methods of examination required for the first object, and more besides; and it is that which is chiefly kept in view in the present discourse.

The optical properties of bodies, properly speaking, include every relation of the bodies to light; but it is by no means every such relation that is available for the object in view. Refractive power, for instance, though constituting, like specific gravity, &c., one of the characters of any particular pure substance, is useless for the purpose of following a substance in a mixture containing it. The same may be said of dispersive power. The properties which are of most use for our object are—first, absorption; and secondly, fluorescence.

Colour has long been employed as a distinctive character of bodies; as, for example, we say that the salts of oxide of copper are mostly blue. The colour, however, of a body, gives but very imperfect information respecting that property on which the colour depends; for the same tint may be made up in an infinite number of ways from the constituents of white light. In order to observe what it is that the body does to each constituent, we must examine it in a pure spectrum. [The formation of a pure spectrum was then explained, and such a spectrum was formed on a screen by the aid of the electric light. On holding a cell containing a salt of copper in front of the screen, and moving it from the red to the violet, it was shown to cast a shadow in the red as if the fluid had been ink, while in the blue rays it might have been supposed to have been water. Chromate of potash similarly treated gave the reverse effect, being transparent in the red and opaque in the blue. Of course the transition from transparency to opacity was not abrupt; and for intermediate colours the fluids caused a partial darkening. Indeed, to speak with mathematical rigour, the darkening is not absolute even when it appears the greatest; but the light let through is so feeble that it eludes our senses. In this way the behaviour of the substance may be examined with reference to the various kinds of light one after another; but in order to see at one glance its behaviour with respect to all kinds, it is merely requisite to hold the body so as to intercept the whole beam which forms the spectrum, to place it, for instance, immediately in front of the slit.]

* The detection of mixtures by the microscopic examination of intermingled crystals properly belongs to the first head, the question which the observer proposes to himself, being, in fact, whether the pure substances forming the individual crystals are or are not identical.

judge from the two examples just given, it might be supposed
e observation of the colour would give almost as much in-
on as analysis by the prism. To show how far this is from
he case, two fluids very similar in colour, port-wine and a so-
of blood, were next examined. The former merely caused a
absorption of the more refrangible rays; the latter exhibited
ll-marked dark bands in the yellow and green. These bands,
oticed by Hoppe, are eminently characteristic of blood, and
a good example of the facilities which optical examination
for following a substance which possesses distinctive characters
nature. On adding to a solution of blood a particular salt of
(any ordinary copper salt, with the addition of a tartrate to
: precipitation, and then carbonate of soda), a fluid was obtained
unlike blood in colour, but showing the characteristic bands of
while at the same time a good deal of the red was absorbed, as
d have been by the copper salt alone. On adding, on the other
acetic acid to a solution of blood, the colour was merely changed
owner red, without any precipitate being produced. Never-
in the spectrum of this fluid the bands of blood had wholly
d, while another set of bands less intense, but still very cha-
stic, made their appearance. This alone, however, does not
whether the colouring matter is decomposed or not by the acid;
blood is an alkaline fluid, the change might be supposed to
rely analogous to the reddening of litmus. To decide the
n, we must examine the spectrum when the fluid is again
d alkaline, suppose by ammonia, which does not affect the
ion bands of blood. The direct addition of ammonia to the
ixture causes a dense precipitate, which contains the colouring
, which may, however, be separated by the use merely of acetic
d ether, of which the former was already used, and the latter
t affect the colouring matter of blood. This solution gives the
haracteristic spectrum as blood to which acetic acid has been
but now there is no difficulty in obtaining the colouring matter
mmoniacal solution. In the spectrum of this solution, the sharp
ion bands of blood do not appear, but instead thereof there is a
band a little nearer to the red, and comparatively vague [this
own on a screen]. This difference of spectra decides the question,
oves that hæmatin (the colouring matter prepared by acid, &c.)
loppe stated, a product of decomposition.

e spectrum of blood may be turned to account still further in
n to the chemical nature of that substance. The colouring
contains, as is well known, a large quantity of iron; and it
be supposed that the colour was due to some salt of iron,
especially as some salts of peroxide of iron, sulphocyanide for
e, have a blood-red colour. But there is found a strong general
lance between salts of the same metallic oxide as regards the
ter of their absorption. Thus the salts of sesquioxide of uranium
a remarkable system of bands of absorption in the more refran-

gible part of the spectrum. The number and position of the bands differ a little from one salt to another; but there is the strongest family likeness between the different salts. Salts of sesquioxide of iron in a similar manner have a family likeness in the vagueness of the absorption, which creeps on from one part of the spectrum to another without presenting any rapid transitions from comparative transparency to opacity and the converse. [The spectrum of sulphocyanide of peroxide of iron was shown for the sake of contrasting with blood.] Hence the appearance of such a peculiar system of bands of absorption in blood would negative the supposition that its colour is due to a salt of iron as such, even had we no other means of deciding. The assemblage of the facts with which we are acquainted seems to show that the colouring matter is some complex compound of the five elements, oxygen, hydrogen, carbon, nitrogen, and iron, which under the action of acids and otherwise, splits into hæmatin and a protein substance.

This example was dwelt on, not for its own sake, but because general methods are most readily apprehended in their application to particular examples. To show one example of the discrimination which may be effected by the prism, the spectra were exhibited of the two kinds of red glass which (not to mention certain inferior kinds) are in common use, and which are coloured, one by gold, and the other by suboxide of copper. Both kinds exhibit a single band of absorption near the yellow or green; but the band of the gold glass is situated very sensibly nearer to the blue end of the spectrum than that of the copper glass.

In the experiments actually shown, a battery of fifty cells and complex apparatus were employed, involving much trouble and expense. But this was only required for projecting the spectra on a screen, so as to be visible to a whole audience. To see them, nothing more is required than to place the fluid to be examined (contained, suppose) in a test tube, behind a slit, and to view it through a small prism applied to the naked eye, different strengths of solution being tried in succession. In this way the bands may be seen by anyone in far greater perfection than when, for the purpose of a lecture, they are thrown on a screen.

In order to be able to examine the peculiarities which a substance may possess in the mode in which it absorbs light, it is not essential that the substance should be in solution, and viewed by transmission. Thus, for example, when a pure spectrum is thrown on a sheet of paper painted with blood, the same bands are seen in the yellow and green region as when the light is transmitted through a solution of blood, and the spectrum thrown on a white screen. This indicates that the colour of such a paper is in fact due to absorption, although the paper is viewed by reflected light. Indeed, by far the greater number of coloured objects which are presented to us, such as green leaves, flowers, dyed cloths, though ordinarily seen by reflection, owe their colour to absorption. The light by which they are seen is, it is true, reflected, but it is not *in reflection* that the preferential selection of certain kinds of rays is made which causes the objects to appear coloured.

Take, for example, red cloth. A small portion of the incident light is reflected at the outer surfaces of the fibres, and this portion, if it could be observed alone, would be found to be colourless. The greater part of the light penetrates into the fibres, when it immediately begins to suffer absorption on the part of the colouring matter. On arriving at the second surface of the fibre, a portion is reflected and a portion passes on, to be afterwards reflected from, or absorbed by, fibres lying more deeply. At each reflection the various kinds of light are reflected in as nearly as possible the same proportion; but in passing across the fibres, in going and returning, they suffer very unequal absorption on the part of the colouring matter, so that in the aggregate of the light perceived the different components of white light are present in proportions widely different from those they bear to each other in white light itself, and the result is a vivid colouring.

There are, however, cases in which the different components of white light are reflected with different degrees of intensity, and the light becomes coloured by regular reflection. Gold and copper may be referred to as examples. In ordinary language we speak of a soldier's coat as red, and gold as yellow. But these colours belong to the substances in two totally different senses. In the former case the colouring is due to absorption, in the latter case to reflection. In the same sense, physically speaking, in which a soldier's coat is red, gold is not yellow but blue or green. Such is, in fact, the colour of gold by transmission, and therefore as the result of absorption, as is seen in the case of gold leaf, which transmits a bluish green light, or of a weak solution of chloride of gold after the addition of protosulphate of iron, when the precipitated metallic gold remains in suspension in a finely-divided state, and causes the mixture to have a blue appearance when seen by transmitted light. In this case we see that while the substance copiously reflects and intensely absorbs rays of all kinds, it more copiously reflects the less refrangible rays, with respect to which it is more intensely opaque.

All metals are, however, highly opaque with regard to rays of all colours. But certain non-metallic substances present themselves which are at the same time intensely opaque with regard to one part of the spectrum, and only moderately opaque or even pretty transparent with regard to another part. Carthamime, murexide, platino-cyanide of magnesium may be mentioned as examples. Such substances reflect copiously, like a metal, those rays with respect to which they are intensely opaque, but more feebly, like a vitreous substance, those rays for which they are tolerably transparent. Hence, when white light is incident upon them the regularly-reflected light is coloured, often vividly, those colours preponderating which the substance is capable of absorbing with intense avidity. But perhaps the most remarkable example known of the connection between intense absorption and copious reflection occurs in the case of crystals of permanganate of potash. These crystals have a metallic appearance, and reflect a greenish light. They are too dark to allow the transmitted light to be examined;

and even when they are pulverized, the fine purple powder they yield is too dark for convenient analysis of the transmitted light. But the splendid purple solution which they yield may be diluted at pleasure, and the analysis of the light transmitted by it presents no difficulty. The solution absorbs principally the green part of the spectrum; and when it is not too strong, or used in too great thickness, five bands of absorption, indicating minima of transparency, make their appearance [these were shown on a screen]. Now, when the green light reflected from the crystals is analyzed by a prism, there are observed *bright* bands, indicating maxima of reflecting power, corresponding in position to the *dark* bands in the light transmitted by the solution. The fifth bright band, indeed, can hardly, if at all, be made out, but the corresponding dark band is both less strong than the others and occurs in a fainter part of the spectrum. When the light is reflected at a suitable angle, and is analyzed both by a Nicol's prism, placed with its principal section in the plane of incidence, and by an ordinary prism, the whole spectrum is reduced to the bands just mentioned. The Nicol's prism would under these circumstances extinguish the light reflected from a vitreous substance, and transmit a large part of the light reflected from a metal. Hence we see that as the refrangibility of the light gradually increases, the substance changes repeatedly, as regards the character of its reflecting power, from vitreous to metallic and back again, as the solution (and therefore it may be presumed the substance itself) changes from moderately to intensely opaque, and conversely.

These considerations leave little doubt as to the chemical state of the copper present in a certain glass which was exhibited. This glass was coloured only in a very thin stratum on one face. By transmission it cut off a great deal of light, and was bluish. By reflection, especially when the colourless face was next the eye, it showed a reddish light visible in all directions, and having the appearance of coming from a fine precipitate, though it was not resolved by the microscope, at least with the power tried. It evidently came from a failure in an attempt to make one of the ordinary red glasses coloured by suboxide of copper, and the only question was as to the state in which the copper was present. It could not be oxide, for the quantity was too small to account for the blueness, and in fact the glass became sensibly colourless in the outer flame of a blowpipe. Analysis of the transmitted light by the prism showed a small band of absorption in the place of the band seen in those copper-red glasses which are not too deep, and therefore a small portion of copper was present in the state of suboxide, *i.e.* a silicate of that base. The rest was doubtless present as metallic copper, arising from over-reduction in the manufacture, and accordingly the blue colour, which would have been purer if the suboxide had been away, indicates the true colour of copper by transmitted light, quite in conformity with what we have seen in the case of gold. Hence, in both metals alike, the absorbing and the reflecting powers are, on the whole, greater for the less than for the more refrangible colours, the

f variation with refrangibility being of course somewhat different
two cases.

ime would not permit of more than a very brief reference to the
l property to which the speaker had referred as useful in tracing
nces in impure solutions—that of fluorescence. The phenomenon
orescence consists in this, that certain substances, when placed
s of one refrangibility, emit during the time of exposure com-
l light of lower refrangibility. When a pure fluorescent sub-
(as distinguished from a mixture) is examined in a pure
um. it is found that on passing from the extreme red to the
and beyond, the fluorescence commences at a certain point of the
um, varying from one substance to another, and continues from
onwards, more or less strongly in one part or another according
particular substance. The colour of the fluorescent light is
to be nearly constant throughout the spectrum. Hence, when in
tion presented to us, and examined in a pure spectrum, we notice
orescence taking, as it were, a fresh start, *with a different colour*,
ly be pretty sure that we have to deal with a mixture of two
scent substances.

might be inferred *à priori*, that fluorescence at any particular
f the spectrum would necessarily be accompanied by absorption,
otherwise there would be a creation of *vis viva*; and experience
that rapid absorption (such as corresponds to a well-marked
um of transparency indicated by a determinate band of absorp-
the transmitted light) is accompanied by copious fluorescence.
xperience has hitherto also shown, what could not have been
ted, and may not be universally true,* that conversely, absorp-
accompanied, in the case of a fluorescent substance, by fluorescence.
om what precedes it follows that the colour of the fluorescent
of a solution, even when the incident light is white, or merely
by absorption, may be a useful character. To illustrate this, the
c light, after transmission through a deep-blue glass, was thrown
utions in weak ammonia of two crystallized substances, æsculin
axin, obtained from the bark of the horse-chesnut, and of which
ter occurs also in the bark of the ash, in which, indeed, it was
iscovered. Both solutions exhibited a lively fluorescence; but
lour was different, being blue in the case of æsculin, and bluish-

---

luorescent substances, like others, doubtless absorb the invisible heat-rays
yond the extreme red, in a manner varying from one substance to another.
if we include such rays in the incident spectrum, we have an example of
on not accompanied by fluorescence. But the invisible heat-rays differ from
f the visible spectrum (as there is every reason to believe) only in the
t the visible rays of one part of the spectrum differ from those of another,
by wave length, and consequently by refrangibility, which depends on wave
Hence it is not improbable that substances may be discovered which absorb
ble rays in some parts of the spectrum less refrangible than that at which the
ence commences; and *mixtures* possessing this property may be made at
. Nevertheless, the speaker has not yet met with a pure fluorescent substance
xhibits this phenomenon.

green in the case of fraxin. A purified solution obtained from the bark exhibits a fluorescence of an intermediate colour, which would suffice to show that æsculin would not alone account for the fluorescence of the solution of the bark.

When a substance possesses well-marked optical properties, it is in general nearly as easy to follow it in a mixture as in a pure solution. But if the problem which the observer proposes to himself be:—Given a solution of unknown substances which presents well-marked characters with reference to different parts of the spectrum, to determine what portion of these characters belongs to one substance, and what portion to another, it presents much greater difficulties. It was with reference to this subject that the second of the objects mentioned at the beginning of the discourse had been spoken of as that the attainment of which was by far the more difficult. The problem can, in general, be solved only by combining processes of chemical separation, especially fractional separation, with optical observation. When a solution has thus been sufficiently tested, those characters which are found always to accompany one another, in, as nearly as can be judged, a constant proportion, may, with the highest probability, be regarded as belonging to one and the same substance. But while a combination of chemistry and optics is in general required, important information may sometimes be obtained from optics alone. This is especially the case when one at least of the substances present is at the same time fluorescent and peculiar in its mode of absorption.

To illustrate this the case of chlorophyll was referred to. An eminent French chemist, M. Fremy, proposed to himself to examine whether the green colour were due to a single substance, or to a mixture of a yellow and a blue substance. By the use of merely neutral bodies, he succeeded in separating chlorophyll into a yellow substance, and another which was green, but inclining a little to blue; but he could not in this way get further in the direction of blue. He conceived, however, that he had attained his object by dissolving chlorophyll in a mechanical mixture of ether and hydrochloric acid, the acid on separation showing a fine blue colour, while the ether was yellow. Now solutions of chlorophyll in neutral solvents, such as alcohol, ether, &c., show a lively fluorescence of a blood-red colour; and when the solution is examined in a pure spectrum, the red fluorescence, very copious in parts of the red, comparatively feeble in most of the green, is found to be very lively again in the blue and violet. Now a substance of a pure yellow colour, and exercising its absorption therefore, as such substances do, on the more refrangible rays, would not show a pure red fluorescence. Either it would be non-fluorescent, or the fluorescence of its solution would contain (as experience shows) rays of refrangibilities reaching, or nearly so, to the part of the spectrum at which the fluorescence, and therefore the absorption, commences; and therefore the fluorescent light could not be pure red, as that of chlorophyll is found to be even in the blue and violet. The yellow substance separated by M. Fremy, by the aid of neutral reagents, is, in fact,

fluorescent. Hence the powerful red fluorescence in the blue and t can only be attributed to the substance exercising the well-known erful absorption in the red, which substance must, therefore, power- absorb the blue and violet. We can affirm, therefore, *à priori*, if this substance were isolated it would NOT be blue, but only a ewhat bluer green. The blue solution obtained by M. Fremy owes, ict, its colour to a product of decomposition, which when dissolved eutral solvents is not blue at all, but of a nearly neutral tint, show- however, in its spectrum extremely sharp bands of absorption.

[G. G. S.]

GENERAL MONTHLY MEETING.

Monday, March 7, 1864.

IAM POLE, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

Joseph Henry Anderson, Esq.
Henry Cook, Esq.
Baldwin Francis Duppa, Esq. J.P.
Thomas Hankey, Esq.
William Helps, M.D.
Arthur James, Esq.
Sir Edwin Landseer, R.A.
Hananel De Leon, M.D.
John J. Lowndes, Esq.
Colin Macrae, Esq.
John Rae, Esq.
Lieut.-Colonel Joseph Carleton Salkeld.
William Spottiswoode, Esq. F.R.S.
Herman Stern, Esq.
Thomas Stevenson, M.B.
Joshua Williams, Esq.
Mrs. Emily Yorke,

elected Members of the Royal Institution.

Jackson Hunt, Esq.
David S. Price, Esq. Ph. D.
John Rae, Esq.

admitted Members of the Royal Institution.

The Secretary announced the following additions to "The Donation d for the Promotion of Experimental Researches" (*see* page 151).

John North, Esq.	£20	0
Miss Anna Swanwick	10	10
John C. Burgoyne, Esq.	20	0
John D. Allcroft, Esq.	20	0

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

The Imperial Government of France—Documents Inédits sur l'Histoire de France:
  Li Livres dou Tresor par Brunetto Latini. Ed. P. Chabaille. 4to. 1863.
  Lettres, &c., du Cardinal de Richelieu. Ed. M. Avenel. Tome V. 1635-7. 4to. 1863.
Architects, Royal Institute of British—Proceedings. 4to. February, 1864.
Asiatic Society of Bengal—Journal, No. 291, 292. 8vo. 1863.
Astronomical Society, Royal—Monthly Notices, No. 3. 1863-4
Bavarian Academy, Royal—Sitzungsberichte, 1863. Band II. Heft 3. 8vo. 1863.
Chemical Society—Journal, 1864. No. 2. 8vo.
Dublin Society, Royal—Journal, No. 30. 8vo. 1863.
Editors—Artizan for February, 1864. 4to.
  Athenæum for February, 1864. 4to.
  Chemical News for February, 1864. 4to.
  Engineer for February, 1864. fol.
  Horological Journal for February, 1864. 8vo.
  Journal of Gas-Lighting for February, 1864. 4to.
  Mechanics' Magazine for February, 1864. 8vo.
  Medical Circular for February, 1864. 8vo.
  Practical Mechanics' Journal for February, 1864. 4to.
  Technologist for February, 1864. 8vo.
Geographical Society, Royal—Proceedings, Vol. VIII. No. 1. 8vo. 1864.
Geological Society—Quarterly Journal, No. 77. 8vo. 1864.
Herschel, Alexander, Esq. (the Author)—Method of Finding the Path of a Meteor. (Proc. Brit. Meteorol. Soc. Nov. 1863.)
Horticultural Society, Royal—Proceedings, 1864. Nos. 2, 3, 4. 8vo.
Imperial Institute of France—Mémoires de l'Académie des Sciences. Tome XXIV. 4to. 1862.
Journal of Mental Science (Editors of the)—Insanity and Crime. 8vo. 1864. (In April No. of Journal, 1864.)
Linnean Society of London—Transactions. Vol XXIV. Part 2. 4to. 1863.
Liverpool Literary and Philosophical Society—Proceedings, No. 17. 8vo. 1863.
Lockyer, Norman, Esq. M.R.I. (the Author)—Observations on the Planet Mars. 4to. (Mem. Astron. Soc. 1863.)
Macloughlin, David, M.D. M.R.I. (the Author)—Proofs of the Non-Existence of a specific Enthetic Disease. (K 90) 8vo. 1864.
Mailly, M. E. (the Author)—Essai sur les Institutions Scientifiques de la Grande-Bretagne et de l'Irlande. (O 14) 16to. 1864.
Photographic Society—Journal, No. 142. 8vo. 1863.
Physical Society of Edinburgh, Royal—Proceedings. 1859-62. 8vo.
Prince, C. Leeson, Esq.—Summary of a Meteorological Journal kept at Uckfield in 1863.
Royal Society of London—Proceedings, No. 60. 8vo. 1864.
Silliman, Professors (the Editors)—American Journal of Science, No. 109. 8vo. 1864.
Scottish Society of Arts, Royal—Transactions, Vol. VI. Part 3. 8vo. 1863.
United Service Institution, Royal—Journal, Nos. 27, 28. 8vo. 1863.
Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Sept. und Oct. 1863. 4to.
Walford, Weston S. Esq. F.S.A. M.R.I.—Horæ Ferales; or, Studies in the Archæology of the Northern Nations. By John M. Kemble. Edited by R. G. Latham and A. W. Franks. 4to. 1863.

WEEKLY EVENING MEETING.

Friday, March 11, 1864.

Sir George Everest, C.B. F.R.S. in the Chair.

The Rev. W. H. Brookfield, M A.

On the Use of Books.

[No Abstract received.]

WEEKLY EVENING MEETING,

Friday, March 18, 1864.

H.R.H. The Prince of Wales, Vice-Patron, in the Chair.

John Tyndall, Esq. F.R.S.

PROFESSOR OF NATURAL PHILOSOPHY, ROYAL INSTITUTION.

Contributions to Molecular Physics.

The speaker had already shown the enormous differences which exist among gaseous bodies, both as regards their power of absorbing and emitting radiant heat. When a gas is condensed to a liquid, or a liquid congealed to a solid, the molecules coalesce, and grapple with each other by forces which were insensible as long as the gaseous state was maintained. But, though the molecules are thus drawn together, the luminiferous ether still surrounds them: hence, if the acts of radiation and absorption depend on the individual molecules, they will assert their power even after the state of aggregation has been changed. If, on the contrary, their mutual entanglement by the force of cohesion be of paramount influence in the interception and emission of radiant heat, then we may expect that liquids will exhibit a deportment towards radiant heat altogether different from that of the vapours from which they are derived.

The first part of the present inquiry is devoted to an exhaustive examination of this question. The speaker employed twelve different liquids, and operated upon five different layers of each, which varied in thickness from 0·02 of an inch to 0·27 of an inch. The liquids were enclosed, not in glass vessels, which would have materially modified the heat, but between plates of transparent rock-salt, which but slightly affected the radiation. His source of heat throughout these comparative experiments consisted of a platinum wire, raised to incandescence by an electric current of unvarying strength. The quantities of radiant heat absorbed and transmitted by each of the liquids at the respective thicknesses were first determined. The vapours of these liquids were subsequently examined, the quantities of vapour employed being proportional to the quantities of liquid traversed by the radiant heat. The result of the comparison was that, for heat of the same quality, the order of absorption of liquids and of their vapours are identical. There was no exception to this law: so that, to determine the position of a vapour as an absorber or radiator, it is only necessary to determine the position of its liquid.

This result proves that the state of aggregation, as far at all events as the liquid stage is concerned, is of altogether subordinate moment—a conclusion which will probably prove to be of cardinal importance in molecular physics. On one important and contested point it has a special bearing. If the position of a liquid as an absorber and radiator determine that of its vapour, the position of water fixes that of aqueous vapour. Water had been compared with other liquids in a multitude of experiments, and it was found that, as a radiant and as an absorbent, it transcends them all. Thus, for example, a layer of bisulphide of carbon 0·02 of an inch in thickness absorbs 6 per cent., and allows 94 per cent. of the radiation from the red-hot platinum spiral to pass through it; benzol absorbs 43 and transmits 57 per cent. of the same radiation; alcohol absorbs 67 and transmits 33 per cent., and alcohol stands at the head of all liquids except one in point of power as an absorber. The exception is *water*. A layer of this substance, of the thickness above given, absorbs 81 per cent., and permits only 19 per cent. of the radiation to pass through it. Had no single experiment ever been made upon the *vapour* of water, we might infer with certainty from the deportment of the *liquid* that, weight for weight, this vapour transcends all others in its power of absorbing and emitting radiant heat.

The relation of absorption and radiation to the chemical constitution of the radiant and absorbent substances was next briefly considered. For the first six substances in the list of those examined, the radiant and absorbent powers augment as the number of atoms in the compound molecule augments. Thus, bisulphide of carbon has 3 atoms, chloroform 5, iodide of ethyl 8, benzol 12, and amylene 15 atoms in their respective molecules; and the order of their power as radiants and absorbents is that here indicated; bisulphide of carbon being the feeblest, and amylene the strongest of the six. Alcohol, however, excels benzol as an absorber, though it has but 9 atoms in its molecule: but, on the other hand, its molecule is rendered more complex by the introduction of a new element. Benzol contains carbon and hydrogen, while alcohol contains carbon, hydrogen, and oxygen. Thus, not only does the idea of *multitude* come into play in absorption and radiation that of *complexity* must also be taken into account. The speaker

ed the particular attention of chemists to the molecule of water ;
portment of this substance towards radiant heat being perfectly
lous, if the chemical formula at present ascribed to it be correct.
r William Herschel made the important discovery that, beyond
mits of the red end of the solar spectrum, rays of high heating
exist which are incompetent to excite vision. The speaker has
ned the deportment of those rays towards certain bodies which
erfectly opaque to light. Dissolving iodine in the bisulphide of
n, he obtained a solution which entirely intercepted the light of
ost brilliant flames, while to the extra-red rays of the spectrum
me iodine was found to be perfectly diathermic. The transparent
hide, which is highly pervious to the heat here employed, exercised
me absorption as the opaque solution. A hollow prism filled
the opaque liquid was placed in the path of the beam from an
ic lamp, the light-spectrum was completely intercepted, but the
pectrum was received upon a screen and could be there examined.
g upon a thermo-electric pile, its presence was shown by the
t deflection of even a coarse galvanometer.

hat, then, is the physical meaning of opacity and transparency
gards light and radiant heat? The luminous rays of the spec-
differ from the non-luminous ones simply in *period*. The
ion of light is excited by waves of ether shorter and more
ly recurrent than those which fall beyond the extreme red. But
hould iodine stop the former and allow the latter to pass? The
r to this question no doubt is that the intercepted waves are those
periods of recurrence coincide with the periods of oscillation
le to the atoms of the dissolved iodine. The elastic forces which
ted these atoms are such as to compel them to vibrate in definite
ls, and, when these periods synchronize with those of the ethereal
, the latter are absorbed. Briefly defined, then, transparency in
s as well as in gases is synonymous with *discord*, while opacity is
ymous with *accord* between the periods of the waves of ether and
of the molecules of the body on which they impinge. All
ary transparent and colourless substances owe their transparency
e discord which exists between the oscillating periods of their
ules and those of the waves of the whole visible spectrum. The
al discord of the vibrating periods of the molecules of *compound*
with the light-giving waves of the spectrum may be inferred
the prevalence of the property of transparency in compounds,
their greater harmony with the extra-red periods is to be in-
from their opacity to the extra-red rays. Water illustrates this
arency and opacity in the most striking manner. It is highly
arent to the luminous rays, which demonstrates the incompetency
molecules to oscillate in the periods which excite vision. It is
ghly opaque to the extra-red undulations, which proves the
ronism of its periods with those of the longer waves.

, then, to the radiation from any source water shows itself to be
ntly or perfectly opaque, it is a proof that the molecules whence

the radiation emanates must oscillate in what may be called extra-red periods. Let us apply this test to the radiation from a flame of hydrogen. This flame consists mainly of incandescent aqueous vapour, the temperature of which, as calculated by Bunsen, is 3,259° C., so that, if transmission augment with temperature, we may expect the radiation from this flame to be copiously transmitted by the water. While, however, a layer of the bisulphide of carbon 0·07 of an inch in thickness transmits 72 per cent. of the incident radiation, and while every other liquid examined transmits more or less of the heat, a layer of water of the above thickness is entirely opaque to the radiation from the flame. Thus we establish *accord* between the periods of the molecules of cold water and those of aqueous vapour at a temperature of 3,259° C. But the periods of water have already been proved to be extra-red—hence those of the hydrogen flame must be extra-red also. The absorption by *dry* air of the heat emitted by a platinum spiral raised to incandescence by electricity was found to be insensible, while that by the ordinary *undried* air was 6 per cent. Substituting for the platinum spiral a hydrogen flame, the absorption by dry air still remained insensible, while that of the undried air *rose to 20 per cent. of the entire radiation.* The temperature of the hydrogen flame was, as stated, 3.259° C.; that of the aqueous vapour of the air was 20° C. Suppose, then, the temperature of aqueous vapour to rise from 20° C. to 3,259° C., we must conclude that the augmentation of temperature is applied to *an increase of amplitude*, and not to the introduction of periods of quicker recurrence into the radiation.

The part played by aqueous vapour in the economy of nature is far more wonderful than hitherto supposed. To nourish the vegetation of the earth the actinic and luminous rays of the sun must penetrate our atmosphere; and to such rays aqueous vapour is eminently transparent. The violet and the extra-violet rays pass through it with freedom. To protect vegetation from destructive chills the terrestrial rays must be checked in their transit towards stellar space; and this is accomplished by the aqueous vapour diffused through the air. This substance is the great moderator of the earth's temperature, bringing its extremes into proximity, and obviating contrasts between day and night which would render life insupportable. But we can advance beyond this general statement, now that we know the radiation from aqueous vapour is intercepted, in a special degree, by water, and, reciprocally, the radiation from water by aqueous vapour; for it follows from this that the very act of nocturnal refrigeration which produces the condensation of aqueous vapour upon the surface of the earth—giving, as it were, a varnish of water to that surface—imparts to terrestrial radiation that particular character which disqualifies it from passing through the earth's atmosphere and losing itself in space.

And here we come to a question in molecular physics which at the present moment occupies the attention of able and distinguished men. By allowing the violet and extra-violet rays of the spectrum to fall upon sulphate of quinine and other substances Professor Stokes has changed the periods of those rays. Attempts have been made to produce a similar result at the other end of the spectrum—to convert the extra-red periods into periods competent to excite vision—but hitherto without success. Such a change of period, the speaker agreed with Dr. Akin in believing, occurs when a platinum wire is heated to whiteness by a hydrogen flame. In this common experiment there is an actual breaking up of long periods into short ones—a true rendering of universal periods visual. The change of refrangibility here effected differs from that of Professor Stokes: firstly, by its being in the opposite direction—that is, from lower to higher; and, secondly, in the circumstance that the platinum is heated by the collision of the molecules of aqueous vapour, and before their heat has assumed the *radiant form.* But it cannot be doubted that the same effect would be produced by radiant heat of the same periods, provided the motion of the ether could be rendered sufficiently intense. The effect in principle is the same, whether we consider the platinum wire to be struck by a particle of aqueous vapour oscillating at a certain rate, or by a particle of ether oscillating at the same rate.

By plunging a platinum wire into a hydrogen flame we cause it to glow, and thus introduce shorter periods into the radiation. These, as already stated, are in discord with water; hence we should infer that the transmission through water will be more copious when the wire is in the flame that when it is absent. Experiment proves this conclusion to be true. Water from being opaque opens a passage to 6 per cent. of the radiation from the flame and spiral. A thin plate of colourless glass, moreover, transmitted 58 per cent. of the radiation from the hydrogen flame; but when the flame and spiral were employed, 78 per cent. of the heat was transmitted. For an alcohol flame Knoblauch and Melloni found glass to be less transparent than for the same flame with a platinum spiral immersed in it: but Melloni afterwards showed that the result was not general—that black glass and black mica were decidedly more diathermic to the radiation from the pure alcohol flame. The reason for this is now obvious. Black mica and black glass owe their blackness to the carbon diffused through them. This carbon, as proved by Melloni, is in some measure transparent to the extra-red rays, and the speaker had succeeded in transmitting between 40 and 50 per cent. of the radiation from a hydrogen flame through a layer of carbon sufficient to intercept the light of the most brilliant flames. The products of combustion of the alcohol flame are carbonic acid and aqueous vapour, the heat of which is almost wholly extra-red. For this radiation, then, the carbon is in a considerable degree transparent, while for the radiation from the platinum spiral, it is in a great measure opaque. By the introduction of the platinum wire, therefore, the transparency of the pure glass and the opacity of its carbon were simultaneously augmented: but the augmentation of opacity exceeded that of transparency, and a difference in favour of opacity remained.

No more striking or instructive illustration of the influence of coincidence could be adduced than that furnished by the radiation from a carbonic oxide flame. Here the product of combustion is carbonic acid; and on the radiation from this flame even the ordinary carbonic acid of the atmosphere exerts a powerful effect. A quantity of the gas, only one-thirtieth of an atmosphere in density, contained in a polished brass tube four feet long, intercepted fifty per cent. of the radiation from the carbonic oxide flame. For the heat emitted by solid sources olefiant gas is an incomparably more powerful absorber than carbonic acid; in fact, for such heat the latter substance, with one exception, is the most feeble absorber to be found among the compound gases. For the radiation from the hydrogen flame, moreover, olefiant gas possesses twice the absorbent power of carbonic acid, but for the radiation from the carbonic oxide flame, at a common tension of one inch of mercury, while carbonic acid absorbs fifty per cent., olefiant gas absorbs only twenty-four. Thus we establish the coincidence of period between carbonic acid at a temperature of 20° C. and carbonic acid at a temperature over 3,000° C., the periods of oscillation of both the incandescent and the cold gas belonging to the extra-red portion of the spectrum.

It will be seen from the foregoing remarks and experiments how impossible it is to examine the effect of temperature on the transmission of radiant heat if different sources of heat be employed. Throughout such an examination the same oscillating atoms ought to be retained. The heating of a platinum spiral by an electric current enables us to do this, while varying the temperature between the widest possible limits. Their comparative opacity to the extra-red rays shows the general accord of the oscillating periods of our series of vapours with those of the extra-red undulations. Hence, by gradually heating a platinum wire from darkness up to whiteness, we gradually augment the discord between it and the vapours, and must therefore augment the transparency of the latter. Experiment entirely confirms this conclusion. Formic ether, for example, absorbs 45 per cent. of the radiation from a platinum spiral heated to barely visible redness; 32 per cent. of the radiation from the same spiral at a red heat; 26 per cent. of the radiation from a white-hot spiral, and only 21 per cent. when the spiral is brought near its point of fusion. Remarkable cases of inversion as to transparency occurred in these experiments. For barely visible redness formic ether is more opaque than sulphuric; for a bright red heat both are equally transparent, while, for a white heat, and still more for a nearly fusing temperature, sulphuric ether is more opaque than formic. This result gives us a clear view of the relationship of the two substances to the luminiferous ether. As we introduce waves of shorter period the sulphuric augments most rapidly in opacity; that is to say, its accord with the shorter waves is greater than that of the formic. Hence we may infer that the molecules of formic ether oscillate, on the whole, more slowly than those of sulphuric ether.

When the source of heat was a Leslie's cube filled with boiling water and coated with lampblack, the opacity of formic ether in comarison with sulphuric was very decided. With this source also the osition of chloroform as regards iodide of methyl was inverted. For white-hot spiral, the absorption of chloroform vapour being 10 per ent., that of iodide of methyl is 16; with the blackened cube as source he absorption by chloroform is 22 per cent., while that by the iodide f methyl is only 19. This inversion is not the result of temperature erely; for when a platinum wire, heated to the temperature of oiling water, was employed as a source, the iodide remained the most owerful absorber. All the experiments hitherto made by the speaker o to prove that from heated lampblack an emission takes place which ynchronizes in an especial manner with chloroform. For the cube at 00° C., coated with lampblack, the absorption of chloroform is more han three times that by bisulphide of carbon; for the radiation from he most luminous portion of a gas-flame the absorption by chloroform s also considerably in excess of that by bisulphide of carbon; while, or the flame of a Bunsen's burner, from which the incandescent carbon articles are removed by the free admixture of air, the absorption by isulphide of carbon is nearly twice that by chloroform. The removal f the incandescent carbon particles more than doubled in this instance he relative transparency of the chloroform. Testing, moreover, the adiation from various parts of the same flame, it was found that for he blue base of the flame the bisulphide was the most opaque, while or all the other portions of the flame the chloroform was most opaque. For the radiation from a very small gas flame, consisting of a blue ase and a small white top, the bisulphide was also most opaque, and ts opacity very decidedly exceeded that of the chloroform when the lame of bisulphide of carbon was employed as a source. Comparing he radiation from a Leslie's cube coated with isinglass with that from similar cube coated with lampblack, at the common temperature of 00° C., it was found that, out of eleven vapours, all but one absorbed he radiation from the isinglass most powerfully; the single exception was chloroform. It may be remarked that, *whenever, through a hange of source, the position of a vapour as an absorber of radiant eat was altered, the position of the liquid from which the vapour was erived was changed in the same manner.*

It is still a point of difference between eminent investigators whether radiant heat, up to a temperature of 100° C., is monochromatic or not. Some affirm this; some deny it. A long series of experiments as enabled the speaker to state that probably no two substances at a temperature of 100° C. emit heat of the same quality. The heat mitted by isinglass, for example, is different from that emitted by lampblack, and the heat emitted by cloth, or paper, differs from both. It is also a subject of discussion whether rock-salt is equally diathermic o all kinds of calorific rays. The differences affirmed to exist by one nvestigator being ascribed by others to differences of incidence from he various sources employed. MM. de la Provostaye and Desains maintain the former view, Melloni and M. Knoblauch maintain the atter. The question was examined by the author without changing anything but the temperature of the source. Its size, distance, and surroundings remained the same, and the experiments proved that rock-salt shares, in some degree, the defect of all other substances; it is not perfectly diathermic, and it is more opaque to the radiation from a barely visible spiral than to that from a white-hot one.

In regard to the relation of radiation to conduction. Defining radiation, internal as well as external, as the communication of motion from the vibrating molecules to the ether, the speaker arrives, by theoretic reasoning, at the conclusion that the best radiators ought to prove the worst conductors. A broad consideration of the subject shows at once the general harmony of the conclusion with observed facts. Organic substances are all excellent radiators; they are also extremely bad conductors. The moment we pass from the metals to their compounds we pass from a series of good conductors to bad ones, and from bad radiators to good ones. Water, among liquids, is probably the worst conductor; it is the best radiator. Silver, among solids, is the best conductor; it is the worst radiator. In the excellent researches of MM. de la Provostaye and Desains the author finds a striking illustration of what he regards as a natural law: that those molecules which transfer the greatest amount of motion to the ether, or in other words, radiate most powerfully, are the least competent to communicate motion to each other, or in other words, to conduct with facility.

[J. T.]

Royal Institution of Great Britain.

WEEKLY EVENING MEETING,

Friday, March 11, 1864.

COLONEL SIR GEORGE EVEREST, C.B. F.R.S. in the Chair.

THE REV. W. H. BROOKFIELD, M.A.,

ONE OF HER MAJESTY'S INSPECTORS OF SCHOOLS.

On Oral Reading.

THE object of the discourse was the advocacy of occasional oral readings by persons possessing leisure and a fair amount of the personal qualifications requisite for such a function, both for parochial purposes as a wholesome and instructive amusement to the poor; and for social purposes as an agreeable recreation for other classes of the community whose more abundant resources do not always exempt them from *ennui* and a craving for a little "indoor relief."

With regard to the poorer classes, the speaker urged that but comparatively few of them on leaving school to earn their livelihood had learned to read with such facility as to read for pleasure; but that such persons would crowd eagerly to the warm, dry schoolroom, bright with gas and gay with cheap decorations, to hear read to them portions of books judiciously selected, and rendered coherent and intelligible by such explanations as might be requisite. It would be quite surprising to those not conversant with the more obscure sections of human life to learn how much intelligence and apprehension there often is where there has been but very scanty instruction. True we are without excuse if we withhold from the poor such education as may be compassed; but still nature is very bountiful in repairing such injustices; and God has printed many books of luminous pages not illegible even to the unlettered rustic; whose intelligence is frequently kept in activity by means independent of what we usually understand by education, so that an audience of peasants with such adaptation on the reader's part as common sense suggests, will often exhibit an appreciation of even literary excellence which would surprise persons not familiar with such experiments. The labour spent on such an enterprise would be amply compensated if only the auditors should go away harmlessly amused; but it might, without extravagance, be hoped that such an amusement would have at least a tendency to something higher, at least a tendency to something better; and might, in its degree, contribute to higher ends than pastime. The immaterial part of their nature might become more consciously developed to themselves; observation might be stimulated—reflection awakened—imagination quickened—possibly slumbering genius aroused—at all events, taste refined—self-respect and respect for their fellow-men cherished—and (would it be too much to say?) a consciousness disclosed within them of filial relationship with the Creator of mind with all its sympathies, and of matter with all its varieties and combinations.

In recommending oral reading as a domestic recreation for the more educated classes, the speaker dwelt chiefly upon the effect which such a practice might in its degree contribute to produce upon the prevailing estimate of style or art in literary composition. He maintained that nothing, as a general rule, would bear reading aloud which was not a work of art—and acceptable as such, independently of the information conveyed to the mind of the hearer. Nine-tenths of the reading of nine-tenths of the readers of the present day is newspaper reading, written for the most part without any profession of art, and for purposes of information only, and such as to read or hear read a second time would be intolerable. The diffusion of this kind of reading contributed to the plausible, prevalent, but pernicious notion, that in composition matter is everything and manner unimportant. He contended, on the contrary, that style or art is the measure of the skill—the intelligibleness—the attraction—the persuasiveness with which incidents, sentiments or opinions are expressed; and suggested that the frequent reading aloud to cultivated auditories of compositions which bore the stamp of general consent as standard works of art, would have a tendency to counteract prevailing impressions disparaging to the cultivation of style, and to recall us to a more just and salutary estimate of its importance.

The speaker asked permission to conclude with an experiment, and to read to the audience—not with any histrionic effort, but simply and plainly, as any gentleman of education might be expected to read it—a classic morsel—written a hundred years ago—containing no sensational incidents, containing, indeed, scarcely any incidents at all, and indebted for its reputation *exclusively* to the style or art with which it was composed. If he should be so fortunate in this experiment as to give his audience even a little pleasure, he considered that he should have established what he had ventured to propound. He then read the story of Le Fevre, from Sterne.

[W. H. B.]

GENERAL MONTHLY MEETING,

Monday, April 4, 1864.

COLONEL PHILIP JAMES YORKE, F.R.S. in the Chair.

Alexander Collie, Esq.
Albert Grant, Esq.
Bernard Augustus Hewitt, Esq.
The Rev. Sir Edward Jodrell, Bart. M.A. F.S.A.
Godfrey Lushington, Esq.
Vernon Lushington, Esq.
Colonel Richard Cornwallis Moore, Royal Artillery, C.B.
James Stern, Esq.
John Tozer, Esq. LL.D. Serjeant-at-Law,

were *elected* Members of the Royal Institution.

Hananel de Leon, M.D.
Thomas Leckie, M.D.
Lieut.-Col. Archibald Parke.
Lieut.-Col. Joseph Carleton Salkeld.
Thomas Stevenson, M.B.

were *admitted* Members of the Royal Institution.

The Secretary announced the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

Samuel R. Solly, Esq. (2nd Donation) . .	£20	0	0
Henry Lainson, Esq.	10	10	0
Col. Philip J. Yorke	10	0	0
John J. Bigsby, M.D.	5	5	0

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

Governor-General of India—Memoirs of the Geological Survey of India:—
Palæontologia Indica. II. 6. III. 1. fol.
Secretary of State for India—Bombay Magnetical and Meteorological Observations in 1861. 4to. 1862.
Architects, Royal Academy of British—Proceedings. 4to. March, 1864.
Astronomical Society, Royal—Monthly Notices, 1863–4, No. 4.
Bavarian Academy, Royal—Sitzungsberichte, 1863. Band II. Heft 2. 8vo. 1836.

Brett, Jacob, Esq.—Illustrated Catalogue of Pictures and Works of Art of John Watkins Brett, Esq. 8vo. 1864.

British Meteorological Society—Proceedings. No. 10. 8vo. 1864.

Chemical Society—Journal for March, 1864. 8vo.

Editors—Artizan for March, 1864. 4to.
Athenæum for March, 1864. 4to.
Chemical News for March, 1864. 4to.
Engineer for March, 1864. fol.
Horological Journal for March, 1864. 8vo.
Journal of Gas-Lighting for March, 1864. 4to.
Mechanics' Magazine for March, 1864. 8vo.
Medical Circular for March, 1864. 8vo.
Practical Mechanics' Journal for March, 1864. 4to.
Technologist for March, 1864. 8vo.

Faraday, Professor, D.C.L. F.R.S.—Memorie della Reale Accademia delle Scienze di Torino. Serie 2ª. Tome XX. 4to. 1863.

Geographical Society, Royal—Proceedings, Vol. VIII. No. 2. 8vo. 1864.

Hart, Ernest, Esq. M.R.I. (the Author)—On some of the Forms of the Disease of the Eye constituting Amaurosis. (K 90) 8vo. 1864.

Huselden, A. F. Esq. (the Author)—Notes on the British Pharmacopœia. 16to. 1864.

Horticultural Society, Royal—Proceedings, 1864. No. 5. 8vo.

Institute of France, Mémoires de l'Académie des Sciences. Tome XXVI. 4to. 1862.

Petermann, A. Esq. (the Editor)—Mittheilungen auf der Gesammtgebiete der Geographie. 1863, No. 12; and 1864, No. 1. 4to.

Philadelphia Academy of Natural Sciences—Proceedings. 1863. No. 3. 8vo.

Photographic Society—Journal, No. 143. 8vo. 1864.

Pilbrow, James, Esq.—Dubuat: Principes d'Hydraulique, &c. Nouvelle Ed. 3 vols. 8vo. Paris, 1816.

Statistical Society of London—Journal, Vol. XXVII. No. 1. 8vo. 1864.

Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Nov. und Dec., 1863. 4to.

Yates, James, Esq. F.R.S. M.R.I.—C. Dowling's Synoptic Table of the Weights and Measures of the Metric System: with Description.

WEEKLY EVENING MEETING,

Friday, April 8, 1864.

THE LORD WENSLEYDALE, Vice-President, in the Chair.

JOHN PERCY, M.D. F.R.S.

On recent Improvements in the Smelting of Iron and the Manufacture of Steel.

[No Abstract received.]

WEEKLY EVENING MEETING,

Friday, April 15, 1864.

SIR HENRY HOLLAND, BART. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

PROFESSOR ABEL, F.R.S.

DIRECTOR OF THE CHEMICAL ESTABLISHMENT OF THE WAR DEPARTMENT.

On the Chemical History and Application of Gun-cotton.

THE history of Gun-cotton affords an interesting illustration of the facility with which the full development of a discovery may be retarded, if not altogether arrested for a time, by hasty attempts to apply it to practical purposes, before its nature has been sufficiently studied and determined.

When Schönbein, in the autumn of 1846, announced that he had discovered a new explosive compound, which he believed would prove a substitute for gunpowder, the statement attracted general attention, and attempts were made with little delay in different countries to apply the material to purposes for which gunpowder hitherto had been alone used. Schönbein, and Böttger (who appear to have discovered Gun-cotton independently, shortly after the former had produced it) lost little time in submitting their discovery to the German Confederation; and a committee was appointed for its investigation, by whom Gun-cotton was eventually pronounced inapplicable as a substitute for gunpowder.

In this country Gun-cotton was experimented with immediately after the method of its preparation was published by Schönbein. Researches were instituted into its nature, preparation, &c., by Porrett and Teschemacher, John Taylor, Gladstone, and others. A few experiments were made on its application as a propelling and mining agent, and the manufacture of the material upon a considerable scale was set on foot by Messrs. Hall, the well-known gunpowder makers at Faversham; a patent having been previously taken out in this country for the production of Gun-cotton according to Schönbein's process. This factory had, however, not been long in operation before a very disastrous explosion occurred at the works, by which a number of men lost their lives, and which was ascribed to the spontaneous ignition of the Gun-cotton, by the jury, who endeavoured to investigate its cause. From that time, the manufacture of Gun-cotton upon any considerable scale was abandoned in England, and no important contributions to our knowledge of this material were made, until, in 1854, Hadow published the results of some valuable investigations, which served to furnish a far more definite knowledge regarding the true constitution and proper method of producing Gun-cotton, than had hitherto existed.

In France, Gun-cotton was also made the subject of experiments as early as the winter of 1846; and its manufacture was carried on at the Government powder-works at Bouchet, near Paris. Some interesting balistic experiments were instituted, under the direction of Piobert, Morin, and other men of eminence, with Gun-cotton, in comparison with different kinds of gunpowder, the results of which indicated, that, for producing equal effects to those furnished by a given weight of Gun-cotton, it was necessary to employ a double quantity of sporting-powder, three times the quantity of musket-powder, and four times the weight of cannon-powder. It was also found that the best results appeared to be obtained by arranging the Gun-cotton so that it should occupy the same space as the charge of gunpowder required to produce an equal effect; and other data were arrived at, which show that the investigators were being led to work in a direction similar to that afterwards so successfully pursued by Baron von Lenk, in Austria. Unfortunately, however, disastrous explosions occurred at the works at Bouchet; one as early as March, 1847, in a drying chamber; and two, following closely upon each other, in 1848. One of these took place in a magazine, near which it was believed that nobody had been for several days; the other occurred also in a magazine where Gun-cotton was being packed; and on this occasion several lives were lost. These disasters appear to have put an end, until quite recently, to experiments with Gun-cotton in France.

After the material had been pronounced upon unfavourably by the Committee of the German Confederation, one of its members, Baron von Lenk, continued to devote himself to its study, and with such success, it appears, that a committee was eventually appointed by the Austrian Government in 1852, to inquire fully into the merits of the material. A sum of money was paid to Schönbein and Böttger, in recognition of the value of their discovery; and an experimental manufactory of Gun-cotton was established at the Castle of Hirtenberg, near Vienna. A particular form of gun was devised by Baron von Lenk, for employment with Gun-cotton, of which a 12-pounder battery was established. The performances of these guns were considered sufficiently satisfactory to warrant the preparation of four more batteries, which were sent to the army of observation in Galicia in 1855, but did not go into active service. It appears that, in consequence of a want of uniformity in the effects of the Gun-cotton, and of an injurious effect upon the guns, added probably to the prejudice entertained against it by the artillery corps, the material fell into disfavour, and its application in cannon was for a time abandoned.

It was received, however, with much greater favour by the engineers, and was applied with great success to mining and submarine operations. Meanwhile Baron von Lenk's labours to perfect Gun-cotton as a material for artillery purposes were unceasing, and, at the close of the Italian war, the subject of its application was again thoroughly reopened at the instigation of Count Degenfeld, then minister of war, who had, at an earlier period, taken an active interest in Baron von Lenk's investigations. After upwards of one year's experiments, a system of rifled field- and mountain- guns, to be employed with Gun-cotton, which had been elaborated by Von Lenk, was introduced into the Austrian service; thirty batteries of these guns were equipped, and it was considered as definitely settled that Gun-cotton would before long be introduced into the service in the place of gunpowder, for artillery purposes.

In 1862, however, an explosion occurred in a magazine at Simmering, near Vienna, where both gunpowder and gun-cotton were stored; and this disaster appears to have fortified to such an extent the arguments which were adduced against the employment of Gun-cotton, by its opponents in the artillery service, that its use in this direction was again put a stop to for a time. Ultimately a committee of investigation was appointed, which consisted in part of eminent scientific men, and which appears, after careful deliberation, to have reported highly in favour of the stability and important properties, as an explosive, of the material, a report which was supported by the favourable opinion entertained of Gun-cotton by the Austrian engineers, in whose name Baron von Ebner prepared a very complete and interesting account of the properties and effects of the agent, with particular reference to mining and other engineering operations.

Gun-cotton appears, therefore, to have been again restored to favour in Austria, but no official accounts have reached England, up to the present time, with regard to its employment in the recent war operations in that country.

In the spring of 1862, full details relating to the manufacture and modes of applying Gun-cotton were communicated by the Austrian Government to that of Her Majesty, and the War Office Chemist was at once instructed to institute experiments upon the manufacture of Gun-cotton, and upon its chemical constitution and stability. In the autumn of that year, General Sabine directed the attention of the British Association to the results obtained with Gun-cotton in Austria; and a combined committee of engineers and chemists was appointed to inquire into the subject. At the meeting of the association in 1863, this committee presented a report, which was based upon information received partly from General von Lenk, who had been permitted by the Austrian Government to visit this country for the purpose of communicating fully with the British Association on the subject, and partly upon the results already arrived at in the experiments instituted by the lecturer, under the direction of the Secretary of State for War. Subsequently, a committee of investigation was appointed by the latter, under the presidency of General Sabine, composed of scientific men connected with the Royal Society and British Association, and of military and naval officers of considerable experience; and this committee has been entrusted with the full investigation of the properties of Gun-cotton, as improved by Baron von Lenk, with reference to its application to military, naval, engineering, and industrial purposes.

The chemical constitution of Gun-cotton, concerning which the opinions of chemists were divided until 1854, has been conclusively established by the researches of Hadow. In the formation of substitution-products, by the action of nitric acid upon cotton or cellulose, three atoms of the latter appear to enter together into the chemical change, and the number of atoms of hydrogen replaced by peroxide of nitrogen in the treble atom of cellulose, $C_{18}\,H_{30}\,O_{15} = 3\,(C_6\,H_{10}\,O_5)$, may be nine, eight, seven, or six, according to the degree of concentration of the nitric acid employed.

The highest of these substitution-products is tri-nitro-cellulose, pyroxilin, or Gun-cotton; $C_{18}\left\{\begin{matrix} H_{21} \\ 9\,NO_2 \end{matrix}\right\}O_{15} = 3\,C_6\left\{\begin{matrix} H_7 \\ 3\,NO_2 \end{matrix}\right\}O_5$; this being the substance first produced by Pelouze in an impure condition, in 1836, by the action of very concentrated nitric acid upon paper, or fabrics of cotton or linen; and afterwards obtained in a purer form by Schönbein, who employed a mixture of concentrated nitric and sulphuric acids for the treatment of cotton-wool, the object of the sulphuric acid being to abstract water of hydration from the nitric acid, and, also, to prevent the action of the nitric acid from being interfered with by the water which is produced, as the chemical transformation of the cotton into Gun-cotton proceeds. The formation of trinitrocellulose is represented by the following equation:

$$\underset{\textit{Cotton.}}{C_6\,H_{10}\,O_5} + \underset{\textit{Nitric acid.}}{3\left\{\begin{matrix} H \\ NO_2 \end{matrix}\right\}O} = \underset{\textit{Gun-cotton.}}{C_6\left\{\begin{matrix} H_7 \\ 3\,NO_2 \end{matrix}\right\}O_5} + \underset{\textit{Water.}}{3\left.\begin{matrix} H \\ H \end{matrix}\right\}O}$$

The lowest substitution-product from cotton, of those named above, appears to have the same composition as the substance which Braconnet first obtained in 1832, by dissolving starch in cold concentrated nitric acid and adding water to the solution, when a white, highly combustible substance is precipitated, to which the name of *Xyloidin* was given. The substitution-products from cotton, intermediate between the lowest and highest, are soluble in mixtures of ether and alcohol, and furnish by their solution the important material *collodion*, so invaluable in connection with photography, surgery, experimental electricity, &c.

According to Schönbein's original prescription, the cotton was to be saturated with a mixture of one part of nitric acid (of specific gravity 1·5) and three parts of sulphuric acid (sp. gr. 1·85), and allowed to stand for one hour. In operating upon a small scale, the treatment of cotton with the acid for that period is quite sufficient to effect its complete conversion into the most explosive product, *pyroxilin* or *trinitrocellulose*; but when the quantity of cotton treated at one time is considerable, especially if it be not very loose and open, its complete conversion into pyroxilin is not effected with certainty, unless it be allowed to remain in the acids for several hours. This accounts in great measure for the want of uniformity observed in the composition of Gun-cotton, and its effects as an explosive, in the earlier experiments instituted; and it is, moreover, very possible that the want of stability, and, consequently even, some of the accidents, which it was considered could only be ascribed to the spontaneous ignition of the material, might have been due to the comparatively unstable character of the lower products of substitution, some of which existed in the imperfectly-prepared Gun-cotton.

The system of manufacture of Gun-cotton elaborated by General von Lenk is founded upon that described by Schönbein; the improvements which the former has adopted, all contribute importantly to the production of a thoroughly uniform and pure Gun-cotton; there is only one step in his process which is certainly not essential, and, about the possible utility of which chemical authorities are decidedly at variance with General von Lenk.

The following is an outline of the process of manufacture of Gun-cotton as practised by Lenk. The cotton, in the form of loose yarn of different sizes, made up into hanks, is purified from certain foreign vegetable substances by treatment for a brief period with a weak solution of potashes, and subsequent washing. It is then suspended in a well-ventilated hot-air chamber until all moisture has been expelled, when it is transferred to air-tight boxes, or jars, and at once removed to the dipping tank, or vessel where its saturation with the mixed acids is effected. The acids, of the specific gravity prescribed by Schönbein, are very intimately mixed, in a suitable apparatus, in the proportion originally indicated by that chemist, *i. e.* three parts by weight of sulphuric acid to one of nitric acid. The mixture is always prepared some time before it is required, in order that it may become perfectly cool. The cotton is immersed in a bath of the mixed acids, one skein at a time, and stirred about for a few minutes until it has become thoroughly saturated with the acids; it is then transferred to a shelf in this dipping trough, where it is allowed to drain, and slightly pressed, to remove any large excess of acid; and is afterwards placed in an earthenware jar, provided with a tightly-fitting lid [which receives six or eight skeins, weighing from two to four ounces each]. The cotton is tightly pressed down in the jar, and, if there be not sufficient acid present just to cover the mass, a little more is added; the proportion of acid to be left in contact with the cotton being about 10½ pounds to one pound of the latter. The charged jars are set aside for forty-eight hours in a cool place, where, moreover, they are kept surrounded by water, to prevent the occurrence of any elevation of temperature and consequent destructive action of the acids upon the Gun-cotton. The same precaution is also taken with the dipping-trough, as considerable heat is generated during the first saturation of the cotton with the acids. At the expiration of forty-eight hours, the Gun-cotton is transferred from the jars to a centrifugal machine, by the aid of which the excess of acid is removed as perfectly as is possible by mechanical means, the Gun-cotton being afterwards only slightly moist to the touch. The skeins are then immersed singly into water, and moved about briskly, so as to become completely saturated with it as quickly as possible. This result is best accomplished by plunging the skeins under a fall of water, so that they become at once thoroughly drenched. If they are simply thrown into water and allowed to remain at rest, the heat produced by the union of a portion of the free acids with a little water would be so great as to establish at once a destructive action upon the Gun-cotton by the acid present. The washing of the separate skeins is continued until no acidity can be detected in them by the taste; they are then arranged in frames or crates and immersed in a rapid stream of water, where they remain undisturbed for two or three weeks. They are afterwards washed by hand, to free them from mechanical impurities derived from the stream, and are immersed for a short time in a dilute boiling solution of potashes. After this treatment they are returned to the stream, where they again remain for several days. Upon their removal they are once more washed by hand, with soap if necessary; the pure Gun-cotton then only requires drying, by sufficient exposure to air at a temperature of about 27° C., to render it ready for use. A supplementary process is, however, adopted by General von Lenk, about the possible advantage or use of which his opinion is not shared by others, as already stated. This treatment consists in immersing the air-dried Gun-cotton in a moderately strong hot solution of soluble glass (silicate of potassa or soda), for a sufficient period to allow it to become completely impregnated; removing the excess of liquid by means of the centrifugal machine; thoroughly drying the Gun-cotton, thus "silicated," and finally washing it once more for some time, until all alkali is abstracted. Lenk considers that, by this treatment, some silica becomes deposited within the fibre of the Gun-cotton, which, on the one hand, assists in moderating the rapidity with which the material burns, and, on the other hand, exercises (in some not very evident manner) a preservative effect upon the Gun-cotton, rendering it less prone to undergo even slight changes by keeping. The mineral matter contained in pure Gun-cotton which has not been submitted to this particular treatment amounts to about one per cent. The proportion found in specimens which have been "silicated" in Austria and in this country, according to Lenk's directions, varies between 1·5 and 2 per cent. It is difficult to understand how the addition of one per cent. to the mineral matter, in the form chiefly of silicates of lime and magnesia (the bases being derived from the water used in the final washing), which are deposited upon and between the fibres in a pulverulent form, can influence, to any material extent, either the rate of combustion or the keeping qualities of the product obtained by Lenk's system of manufacture.

Gun-cotton prepared according to the system just described is exceedingly uniform in composition. The analyses of samples prepared both in Austria and at Waltham Abbey have furnished results corresponding accurately to those required by the formula $C_6 \left\{ \begin{matrix} H_7 \\ 3\,N\,O_3 \end{matrix} \right\} O_5$. In its ordinary air-dry condition it contains, very uniformly, about two per cent. of moisture; an amount which it absorbs again rapidly from the air, when it has been dried. The proportion of water existing in the purified air-dried cotton, before conversion, is generally about six per cent. When pure Gun-cotton is exposed to a very moist atmosphere, or kept in a damp locality, it will absorb as much as from six to seven per cent.; but, if it be then exposed to air of average dryness, it very speedily parts with all but the two per cent. of moisture which it contains in its normal condition. It may be preserved in a damp or wet state apparently for an indefinite period without injury; for, if afterwards dried by exposure to air, it exhibits no signs of change.

In these respects it possesses important advantages over gunpowder. The normal proportion of hygroscopic moisture in that substance varies between three quarters and one per cent.; but if exposed in any way to the influence of a moist atmosphere, it continues to absorb water until, however firm the grains may have originally been, it becomes quite pasty. It need scarcely be stated that, when once gunpowder has become damp, it can no longer be restored to a serviceable condition, except by being again submitted to the processes of manufacture, starting almost from the commencement.

Perhaps the most vital considerations, bearing upon the possibility of applying Gun-cotton to important practical purposes, are those which relate to the risk likely to be incurred in its manufacture, and preservation in large quantities. The manufacture of Gun-cotton is unquestionably much safer than that of gunpowder; in fact, there is no possibility of accident until the final drying process is reached; as, in all the other stages, the material is always wet, and therefore harmless. With the adoption of a proper system of warming and ventilation, in the drying-chamber, the last operation is certainly not a more dangerous one than that of drying gunpowder. The question of the safe preservation of Gun-cotton cannot as yet be so easily and satisfactorily disposed of. Specimens of Gun-cotton exist, which were prepared according to Schönbein's directions in 1846, and which have undergone no change whatever; on the other hand, it is well known that Gun-cotton, which was believed to have been perfectly purified, has become extremely acid and has even undergone so complete a decomposition, as to have become converted into oxalic acid and other organic products, when preserved in closed vessels, and especially when exposed continually, or occasionally, to light. This susceptibility to chemical change has been particularly observed in samples of Gun-cotton known to consist chiefly, or to contain some proportion, of the less explosive or lower substitution-products (*i. e.* Gun-cotton specially prepared for the manufacture of collodion). Hence, it is very possible that such instances, as are considered to have been well authenticated, of the spontaneous ignition of Gun-cotton, when stored in considerable quantities, or during exposure to very moderate heat, may have arisen not simply from an imperfect purification of the material, but also from the more or less imperfect conversion of cotton into the most explosive and apparently most stable product.

There is no doubt that the improvements effected in the system of manufacture of Gun-cotton have been instrumental in rendering it far more stable in character than it was in the early days of its production upon a considerable scale. At the same time, although General von Lenk and its warmest partisans consider that its unchangeability can no longer be disputed, a greater amount of experience, combined with more searching investigations than have hitherto been instituted, upon the possibility of its undergoing change when under the influence of moderate heat, alone or combined with that of moisture, and when preserved under a variety of other conditions, are unquestionably indispensable before its claims to perfect permanence can be considered as properly established. It has already been ascertained by very recent experiments of the lecturer, that Gun-cotton prepared and purified with the most scrupulous care, speedily undergoes some amount of decomposition when exposed to temperatures ranging from 32° to 66° C.; it remains to be seen whether such decomposition, if once established by exposure of Gun-cotton to some temperature within the above limits, will cease permanently, when the material is removed from the influence of heat; or whether precautions or efficient supplementary processes can be adopted in the manufacture, to counteract the tendency to change exhibited by Gun-cotton under the above circumstances. These are only some of the points which need patient investigation before it is positively known whether the requisite confidence can be placed in the material, as an agent susceptible of substitution for gunpowder.

It has been ingeniously argued that a slight indication of spontaneous change in Gun-cotton need give rise to no alarm, because gunpowder is also liable to slight spontaneous change, reference being made to the fact that a very minute proportion of the sulphur in that material has been noticed to undergo oxidation. It need hardly be stated that such a minute change cannot have the slightest effect upon the stability of the mechanical mixture, gunpowder, in which variations, as regards purity and proportions of ingredients, occur, to an extent which renders this change of absolute insignificance; whereas in the case of Gun-cotton as now manufactured, the development of acid, however minute the proportion, may very possibly give rise to an important disturbance of chemical equilibrium, in a compound, the stability of which is based upon the perfect uniformity of its composition; and it may also be at once productive of further change, by the tendency which the acid itself has to exert chemical action upon certain elements of the Gun-cotton.

The general properties of Gun-cotton as an explosive agent have long been popularly known to be as follows: when inflamed or raised to a

erature ranging between 137° and 150° C. it burns with a bright
and large body of flame unaccompanied by smoke, and leaves no
ciable residue. It is far more readily inflamed by percussion than
owder; the compression of any particular portion of a mass of
Gun-cotton between rigid surfaces will prevent that part from
ing when heat is applied. The products of combustion of Gun-
n, in air, redden litmus paper powerfully; they contain a con-
able proportion of nitric oxide, and act rapidly and corrosively upon
and gun-metal. The explosion of Gun-cotton, when in the loose,
d condition, the form in which it was always prepared in the early
of its discovery, resembles that of the fulminates in its violence
instantaneous character; in the open air it may be inflamed
in actual contact with gunpowder, without igniting the latter;
confined space, as in a shell or the barrel of a gun, the almost
ntaneous rapidity of its explosion, when in this form, produces
s which are highly destructive as compared with those of Gun-
ler, while the projectile force exerted by it is comparatively small.

any attempts have been made, from time to time, to diminish the
ity of explosion of Gun-cotton; but the only one attended by any
s, is that which, in General von Lenk's hand, has led to the develop-
of a system of mechanical arrangement of Gun-cotton, as ingenious
imple as it is effective. By manufacturing the cotton into yarn,
ifferent thicknesses and degrees of compactness or fineness of
, *before* its conversion into Gun-cotton, this material is at once
ned in forms which not only burn with great regularity and much
apidity, when used in the original condition, than the loose Gun-
n wool, but which also, when employed in the form of reels, wound
or less compactly, or when converted into plaits or hollow ropes,
be made to burn gradually, in a manner similar to gunpowder, or
sh into flame instantaneously, exerting an explosive action very
xceeding that of the latter. The modifications in the nature and
e of explosive force exerted by Gun-cotton, which are essential
ts application to military and industrial purposes as a substitute
owder, are, therefore, arrived at by means of very simple varia-
of the mechanical condition of the material. Thus, to obtain
gradual action essential for the employment of Gun-cotton in
on, cartridges are made up of coarse yarn, which is wound firmly
d a hollow cylinder of wood, of dimensions regulated by the size
e gun-chamber and the weight of the charge used, the best result
g obtained by so arranging the latter that the cartridge entirely
the space allotted to the charge in the gun. Similarly, small-arm
idges are made of cylindrical plaits of fine yarn or thread, which
tted compactly in layers, one over the other, upon a small cylinder
indle of wood. In both of these arrangements the combustion of
charge can proceed only from the external surfaces towards the
ior of the cartridge. On the other hand, the charges for shells,
ich the most rapid explosion is most effective; and the priming
uick-matches which are intended for firing several charges simul-

taneously and almost immediately upon the application of flame, consist of cylindrical, hollow, and moderately compact plaits (similar to lamp-wicks), made of Gun-cotton-thread, or very fine yarn. These plaits are produced in pieces of any length, and when employed as quick-matches are compactly enclosed in cases of waterproof canvas or other similar materials. The charges to be used in mines, in which the most destructive effects are aimed at, consist of pieces of very firmly-twisted rope, with a hollow core along the centre, the number of strands of which it is composed varying with the size of the charge to be used. For quarrying and blasting purposes, small lengths of the rope are employed singly; for military operations (demolition of works, &c.), it is packed into moderately stout cases of sheet-metal. In these hollow ropes and plaits of Gun-cotton, the flame produced by the burning of that portion to which heat is applied, penetrates at once to the interior and into the interstices of the charge, and hence the entire mass of Gun-cotton is converted into gas and vapour, with almost instantaneous rapidity. A striking illustration of the very opposite effects which can be produced by very simple modifications in the mechanical arrangement of the Gun-cotton is afforded by the following experiment: if two or three strands of Gun-cotton-yarn be very loosely twisted together and inserted into a tube of glass, or other material, in which they fit so loosely as to be readily drawn backwards and forwards, upon applying heat to a projecting portion at one end of the tube, the Gun-cotton thus arranged will explode with great violence, completely pulverising the tube, if it be of glass; and the combustion will take place with such almost instantaneous rapidity that small portions of unburnt Gun-cotton will actually be scattered by the explosion. But when two or more strands of the same Gun-cotton-yarn are tightly twisted, singly in the first instance, then made up into a firm cord, solid throughout, and enclosed in a glass tube or some other description of case into which the cord fits very tightly, if a protruding end of the Gun-cotton be then inflamed, the cord will burn with moderate rapidity until the fire reaches the opening of the case, when the combustion will pass over from the ordinary kind to a form which can only be described as a smouldering; the lighted extremity of the Gun-cotton simply glows within the case, while a steady jet of flame (furnished by the combustible gases evolved from the Gun-cotton) continues to burn at the open extremity of the case, until the contents of the latter are consumed. The Gun-cotton not only burns extremely slowly under these conditions, but also with the greatest regularity, so that the rate of combustion of a given length of the enclosed cord may be accurately timed. The rapidity of combustion of Gun-cotton arranged in this given form may be regulated by the number of strands in a cord, and the degree of their compactness, and it is by this new modification of General von Lenk's system of arranging Gun-cotton that the lecturer has succeeded in applying this material to the production of slow-matches and time-fuzes; uses for which it had not previously been found suitable.

Reference has just been made to inflammable gases evolved by Gun-cotton while it undergoes a very slow combustion. The composition of Gun-cotton renders it self-evident that, under any circumstances, the explosion of this substance must be accompanied by the production of a very considerable proportion of carbonic oxide. The large body of flame, always observed when Gun-cotton is ignited under ordinary circumstances, is principally due to the combustion of carbonic oxide and, probably also, of small quantities of carbo-hydrogen compounds which, together with minute suspended particles of the mineral matter contained in the Gun-cotton, give to the flame its brightness. If a tuft of Gun-cotton be ignited in a capacious and somewhat deep vessel, the flame actually resulting from the burning of the tuft may be distinctly seen surrounded by a large body of flame, produced by the burning gases, which continue apparent for a very appreciable time after the disappearance of the flash of flame furnished by the explosion of the Gun-cotton. If similar tufts be ignited in atmospheres of hydrogen, nitrogen, carbonic acid, coal gas, &c., the combustion of the Gun-cotton is only accompanied by a very small and pale flame, of instantaneous duration. Similarly, if Gun-cotton be ignited in a vessel which has been previously exhausted, to at any rate one-half the ordinary atmospheric pressure, the proportion of air, and therefore oxygen, present when the Gun-cotton is ignited, does not suffice to effect the combustion of any large proportion of the inflammable gases generated, and hence the explosion of the Gun-cotton is attended only by a small pale flame. If, however, the vessel be filled with oxygen and then exhausted to an equal or even a lower degree, it is filled with flame of dazzling brightness directly the ignition of the Gun-cotton is effected.

The one modification, just referred to, of the phenomena which attend the ignition of Gun-cotton in a rarefied atmosphere is not the only result observed in experiments of this kind. Various curious effects may be obtained; their nature being determined by the degree of rarefaction of the atmosphere, the mechanical condition of the Gun-cotton, its position with reference to the source of heat employed, and other variable elements in the experiments. A brief account of some of the principal of these phenomena may not be without interest.

In the experiments with a tuft of Gun-cotton in rarefied air, spoken of just now, a perceptible interval is observed between the first application of heat (by passage of a voltaic current through a platinum wire enclosed in the tuft) and the first appearance of ignition of the Gun-cotton; moreover, the pale flame observed when the latter does burn, is of very perceptibly longer duration than that of the bright flash which attends the explosion of Gun-cotton in air, under ordinary conditions. If instead of using the Gun-cotton in the form of a tuft, a short piece of the Gun-cotton yarn be employed in the experiment, and laid on a support so that it rests upon the wire by which it is to be ignited, the pale flame of the burning Gun-cotton will travel along towards the two extremities of the piece of yarn with a degree of slowness corresponding to the extent of rarefaction of the atmosphere.

These results are in perfect accordance with the observation (first made by Quartermaster Mitchell, afterwards fully examined into by Frankland, and recently amplified by Dufour), that the rate of burning of time-fuzes is influenced by the altitude at which they are burned, or, in other words, by the degree of pressure of the atmosphere, the combustion being proportionately slow with every decrement of pressure of the air. When the platinum-wire is first raised to a red heat, in the centre of the tuft of Gun-cotton enclosed in a highly-rarefied atmosphere, the products resulting from the decomposition of that portion of the material which is in close contact with the wire, immediately distribute themselves through the rarefied space, conveying away, and rendering latent by their great expansion, the heat furnished by the platinum wire and that which results from the chemical change. The increase of pressure within the confined space, by the generation of the gases and vapours, on the one hand, and, on the other hand, the effect of the heated gases, which escape, upon the particles of Gun-cotton through which they permeate, result, in the course of time, in the ignition of the mass; but even then the Gun-cotton burns only slowly, because, in consequence of the rapidity with which the resulting gases and vapours escape and expand, much of the heat essential for the maintenance of the combustion is at once conveyed away. The latter result is strikingly exemplified by an experiment in which Gun-cotton yarn is substituted for the tuft of carded Gun-cotton; indeed, if the atmosphere be very highly rarefied (to 0·6 in inches of mercury) and a sufficient length of the Gun-cotton yarn (4 or 5 inches) be employed in the experiment, the burning of the material, induced by the heated wire, will proceed so slowly, that the heat resulting from the chemical change will be conveyed away from the burning surface, by the gases generated, much more rapidly than it is developed, so that the Gun-cotton will actually become extinguished when only a small portion of it has been burned.

A very similar result is obtained if *gunpowder*, either in the form of grains or of one large mass, is exposed to the action of an incandescent platinum wire imbedded in it, the pressure of the atmosphere, in the apparatus in which the experiment is made, being reduced to between 0·6 and 2, in inches of mercury. The portion of Gunpowder contiguous to the heated wire will fuse; vapours of sulphur will be evolved in the first instance, and, subsequently, the charcoal will be oxidised by the nitre, bubbles of gas escaping from the fused mass. The vapours and gases thus generated convey away rapidly the heat provided by the wire and developed by the chemical action; and at the same time the change which the gunpowder undergoes diminishes its explosive character, so that its partial ignition or explosion will only be effected after the lapse of several minutes, and, if it be in the form of grains, the explosion of the particles contiguous to the wire will have the effect of scattering the remainder without igniting it.

The great reduction in the rapidity of combustion of Gun-cotton is not the only result observed when small quantities of that substance

ied to heat under diminished atmospheric pressure. In the
hly-rarefied atmospheres (from 0·5 to 1 inch), the only indica-
ded of the burning of the Gun-cotton is the appearance of a
green glow, like a phosphorescence, immediately surrounding
which is undergoing decomposition. When the pressure of
sphere is slightly increased, a faint yellow lambent flame ap-
yond the green glow, at a short distance from the point of
sition; and, in proportion as the atmosphere is less rarefied,
yellow flame increases in volume, while the green phospho-
becomes less and less apparent until it seems to be completely
ed. Lastly, when the pressure of the atmosphere is compara-
eat (= 25 or 26, in inches of mercury), the Gun-cotton burns
ordinary bright flame, though less rapidly, of course, than it
er normal conditions of atmospheric pressure. There is no
at this bright flame is due to an almost instantaneous secondary
on (in the oxygen supplied by the air in the apparatus) of the
ible gases evolved by the decomposition. On the other hand
action of the small pale flame, observed when Gun-cotton is
in more highly rarefied air, or in atmospheres of gases which
upply oxygen for combustion, is most probably due to the
n of a mixture of gases (by the change which Gun-cotton
s under these conditions) which contains not only combustible
ich as carbonic oxide, but also a proportion of oxidizing gases
le of nitrogen or even oxygen); such a mixture, having self-
ble properties, will receive sufficient heat from the burning
ton to become ignited, except when the atmosphere in which
ge takes place is so highly rarefied that the heat is immediately
d and the gases evolved become highly attenuated, as already
l.

ll be readily conceived that the mechanical state of the Gun-
i. e. the particular form in which it is employed), like other
conditions which have been alluded to, will greatly influence
re of phenomena observed, when this substance is ignited in
n various gases, either at ordinary or diminished pressures.
y be exemplified by the following experimental illustrations.
en stated that when a tuft of carded Gun-cotton is ignited in
acid, carbonic oxide, nitrogen, coal gas, hydrogen, and other
burns only with a pale yellow flame; this flame, when fur-
y equal quantities of Gun-cotton, is much smaller in an
ere of hydrogen than it is, for example, in carbonic acid; a
h must be ascribed to the comparatively very rapid diffusion of
rated gases when hydrogen is used. In operating with pieces
otton yarn, instead of employing loose tufts, the material, when
y a red-hot wire in atmospheres of carbonic acid, nitrogen in
oxide, burns much more slowly than it does in air under the
nditions; and its combustion is accompanied only by a very
or pointed tongue of pale flame, which is thrown out in a line
burning extremities of the piece of yarn. In the same way,

if the yarn is enclosed in a tube or other vessel, through which gases are circulating, and from which one extremity cf the Gun-c protrudes, when the latter is lighted it will burn in the ordinary ner only until it reaches the opening of the tube, when the for combustion will at once be changed to that just described. If, how corresponding experiments are made in atmospheres of hydrog coal gas, the Gun-cotton yarn will burn in the slow manner descr but only for a very brief period; indeed, it ceases to burn at all al instantaneously, just as it does when ignited in a very highly-ra atmosphere. This result is not due to the high diffusive powers o gas in which the Gun-cotton is burned, as it may be obtained eq in open and in perfectly-closed vessels; it can therefore only b cribed to the high cooling powers, by convection, of the gases empl Pure nitrogen, as stated just now, allows the Gun-cotton yarn to in the slow manner, but if mixed with one-fourth its volume of hy gen, it arrests the combustion of the material, just like coal gas or hydrogen.

A rapid current of air will also effect the transformation of the c bustion of Gun-cotton from the ordinary to the slow form, if the be enclosed in a moderately wide glass tube, with one end protr from the tube, so that it may be inflamed in the ordinary manner; unless the current be very rapid, an explosive mixture of air, and inflammable gases generated from the Gun-cotton, may be produc the tube, and become ignited, in which case the Gun-cotton will f into flame instantaneously, and the tube will be shattered by explosion. If, however, a long piece of thin Gun-cotton yarn passed through a small narrow glass tube, one or two inches long, i which it fits so loosely that it may be drawn through very easily, change in the form of combustion is effected with certainty, and w out the aid of a current of air. When the Gun-cotton, thus arra and placed upon a flat surface, is inflamed at one extremity, it bu as usual until it reaches the one opening of the tube; the slow for combustion then takes place within the tube, and the Gun-cotton w continue to burn in the slow manner, emitting only the small to of flame, after the combustion has reached the portion of yarn on other side of the tube, which will be entirely burned in this pec manner. In fact, to change the ordinary into the slow form of c bustion of the Gun-cotton yarn *in open air*, it is only necessary to p a piece of the material through a perforation in a diaphragm of w card-board, or paper, and to allow it to rest upon a flat surface on b sides of the diaphragm. The Gun-cotton will burn as usual u one side of the screen, until its combustion reaches the perforati when the large bright flame will vanish and the Gun-cotton upon other side of the screen will burn in the slow manner to the end.

The two last experiments show, that if the combustible mixture gases, evolved by the action of heat upon Gun-cotton when it inflamed in open air, are prevented, even for the briefest space of ti from completely enveloping the burning extremity of the yarn

or, in other words, if they are forced for an instant to escape
in a direct line with the burning surface of Gun-cotton from
they are emitted, those particles of the latter which are in
liate proximity to the burning portion cannot be raised to the
rature necessary for their rapid and more complete combustion,
nce the gases themselves are in turn not supplied with sufficient
or their ignition. Now, as the gases which escape unburned
y away a very large portion of the heat developed by the
orphosis of the Gun-cotton, it is impossible for the latter to
ue to burn otherwise than in the slow and imperfect manner.
wever, a flame or highly-heated body be held in the path of the
as they escape, they will at once be ignited and the yarn will
into the ordinary form of combustion. The correctness of this
ation may readily be demonstrated by two or three simple
ments. Thus, if a piece of loose or open Gun-cotton yarn is
yed in place of the compact material which furnishes the
just described, it is very difficult, or even impossible, to cause
pid combustion to pass over into the slow form, because the
ng gases cannot be diverted all into one direction, and cannot,
ore, be prevented from transmitting the heat necessary for
t combustion from particle to particle of the material. Again,
iece of the compactly-twisted Gun-cotton yarn, placed upon a
rface, is inflamed in the usual manner, and a jet of air is then
ed in a line with the Gun-cotton so as to meet the flame, the
will appear to be blown out, though the cotton still burns;
, the burning gases are prevented for an instant from completely
ping the extremity of the Gun-cotton, and hence the combus-
t once passes from the quick to the slow form. Conversely, if,
the yarn has been made to burn in this slow manner, a very
current of air be directed against the burning portion, so as to
back upon the latter the gases which are escaping, thus impeding
pid abstraction of heat, the Gun-cotton will very speedily burst
he ordinary form of combustion, because, under these circum-
s, the gases are almost immediately raised to the temperature
ary for their combustion. In the same way, if a piece of the yarn
l upon a board be made to burn in the slow manner, and one
f the board be gradually raised, so that the burning extremity of
un-cotton is the lowest, the latter will burst into flame as soon as
ard has been raised to a position nearly vertical, so that the
ng gases flow back upon the burning surface.

he slow or imperfect form of combustion may be at once induced
compact Gun-cotton yarn, in open air, by applying to any part
Gun-cotton a source of heat not sufficiently great to inflame the
generated. A wire, or metal rod, heated to any temperature
en 135° C. to just below visible redness, or the spark of a thin
of smouldering string, will invariably produce the result described.
urse this effect, like most of the phenomena described, is to a
erable extent dependent upon the mechanical condition of the

Gun-cotton, upon the relation between the *quantity* as well as the *degree* of heat applied and the amount of surface of the Gun-cotton, and upon other conditions. While a small spark, or a thin platinum wire heated to full redness, only induces slow combustion in the compact Gun-cotton yarn, a thick rod of iron, heated only to dull redness, will invariably inflame it in the ordinary manner. A piece of open yarn cannot be ignited so as to burn in the slow manner; on the other hand, the more compactly the Gun-cotton is twisted, the more superficial is the slow form of combustion induced in it: indeed, the Gun-cotton may be rendered so compact that it will simply smoulder in open air, if ignited as described, leaving a considerable carbonaceous residue; and the heat resulting from this most imperfect combustion will sometimes be abstracted by the escaping gases more rapidly than it is developed, so that the Gun-cotton will then actually cease to burn, even in open air, after a short time.

The remarkable facility with which the effect of heat upon Gun-cotton may be modified, so as even to produce results totally opposite in their characters, as exemplified by some of the experiments which have been described, renders it easily conceivable that this material may be made to produce the most varied mechanical effects, when applied to practical purposes; that it may indeed be so applied as, on the one hand, to develope a force, very gradual in its action, which may be directed and controlled at least as readily as that obtained by the explosion of gunpowder, while, on the other hand, it may be made to exert a violence of action and a destructive effect far surpassing those of which gunpowder is susceptible. The results arrived at in Austria, which show that Gun-cotton may be made to produce effects from three to eight times greater than those of gunpowder, cease to be surprising after a study of the chemical and physical characteristics of this interesting explosive agent.

The products obtained by the explosion of Gun-cotton, and its decomposition under various conditions, have as yet been very imperfectly studied, but there is little doubt that they vary in their nature almost as greatly as the phenomena which attend the exposure of the material to heat under different circumstances. It is well known that, when Gun-cotton is inflamed in the open air, there is produced (in addition to water, carbonic oxide, carbonic acid, and nitrogen) a considerable proportion of binoxide of nitrogen, so that the gaseous mixture assumes a red-brown tinge, and becomes very acid when it mixes with air. The products of the different forms of imperfect combustion which Gun-cotton has been described as susceptible of undergoing, are undoubtedly much more complex in their character than those just referred to. They include at times a proportion of some substances, not yet examined, which make their appearance as a white vapour or smoke; cyanogen can readily be detected in all the products of imperfect combustion: the proportion of binoxide of nitrogen is generally so large that the gaseous product becomes very highly coloured when mixed with air: peroxide of nitrogen has also een observed in some instances; lastly, there is little doubt that the roducts occasionally include a proportion of oxidizing gases.

The products which have just been alluded to are the results of the ecomposition of Gun-cotton either at ordinary or diminished atmopheric pressures; when the explosion of the material is effected in a onfined space, in such a manner that the main decomposition takes lace under pressure, the metamorphosis which the material undergoes of a more simple and complete character.

It has been found by Karolyi that, when Gun-cotton is exploded y voltaic agency in a shell which is burst by the explosion, and which enclosed within an exhausted chamber, so that the products of deomposition are collected without danger, the results obtained under ese conditions are comparatively simple; the analysis of the contents f the chamber, after the explosion, showed that they consisted of caronic acid 20·82 per cent., carbonic oxide 28·95, nitrogen 12·67, ydrogen 3·16, marsh gas 7·24, water 25·34, and carbon 1·82. The ecomposition of Gun-cotton under these conditions (which are similar those of its explosion when employed as a destructive agent) appears, erefore, not to be attended by the production of any oxide of nitrogen. he lecturer found, in some preliminary experiments made under the ame conditions as those of Karolyi, that only a minute proportion of inoxide of nitrogen was produced. These results, when compared ith those obtained by the ignition of Gun-cotton in open air and arefied atmospheres, show that, just as the decomposition of this maerial is of a more complicated and intermediate character, in proportion its combustion is rendered imperfect by diminution of pressure or ther circumstances, so, conversely, the change which it undergoes will e the more simple, and its conversion into gaseous products the more omplete, the greater the pressure, beyond normal limits, under which is exploded: that is to say, the greater the resistance offered to the enerated gases upon the first ignition of a charge of Gun-cotton (and onsequently the higher the temperature at which the decomposition of e confined Gun-cotton is effected). It is therefore readily intelligible at the notions hitherto generally entertained with regard to the very oxious character of the products of explosion of Gun-cotton and their owerfully corrosive action upon metals—based as these notions have een upon the effects observed on exploding Gun-cotton in open air—ave been proved to be erroneous by the results of actual application f Gun-cotton to artillery and other purposes. The foregoing coniderations contribute, moreover, to the ready explanation of the fact, stablished by the experiments in Austria, that the destructive effect f Gun-cotton is greatly increased, within certain limits, by increasing e resistance which the products of explosion have to overcome before hey can escape into the air.

The conditions (of temperature, pressure, &c.) which influence the ature of the decomposition of Gun-cotton, exert, unquestionably, a imilar influence upon the nature of the explosion of *gunpowder*, and pon the mechanical effects which the products are capable of exerting.

Observations made by the lecturer, in experiments upon the ignition of gunpowder in rarefied atmospheres, point to the existence of products of comparatively complicated character among those found by the gradual decomposition of that material under the conditions described. The earlier investigations (Gay-Lussac, Chevreul, &c.), of the products of explosion of gunpowder, represent these as being of a very simple character, and in harmony with the theory that gunpowder is converted essentially by its explosion into carbonic acid (or a mixture of that gas and carbonic oxide), nitrogen and sulphide of potassium. But, more recent experimenters, Bunsen and Schischkoff, who have made a very elaborate examination of the products which they obtained by the explosion of gunpowder, represent the change to be one of a very complicated character; fix the percentage of solid substances found at a much higher figure than that hitherto accepted, and show that the sulphide of potassium, which has been considered as the principal of these products, was only produced in very small proportion, in their experiments. The conditions under which these chemists exploded the gunpowder did not, however, correspond at all in their character to those under which gunpowder is exploded in actual practice, and would, therefore, be very likely to furnish results greatly at variance with those produced when a charge of powder is fired in a gun, a shell, or a mine. That sulphide of potassium is abundantly produced, upon the discharge of a fire-arm, appears beyond doubt; it may be readily detected in the solid matter which remains in the barrel near the breech; it may be found deposited in considerable quantity near the muzzle of the arm, and there appears strong reason for believing that the flash of flame, observed at the mouth of a fire-arm upon its discharge, is due in part to the ignition, as it comes into contact with the air, of sulphide of potassium, which has been *vapourized* by the heat of the explosion, and is thus mixed with the escaping gases.

In comparing the effects of Gun-cotton, as an explosive agent, with those of gunpowder, and in basing theories, with regard to the difference in the mechanical effects exerted by the two, upon the analytical results of the products of their explosion which have been obtained up to the present time, it is necessary to proceed with great caution: for exceptional results cannot form any sound basis for correct theories or tenable arguments. It can only lead to incorrect conclusions, which may considerably retard the thorough investigation of a most important subject, if the facts be ignored or lost sight of, that, *firstly*, the conditions which practically influence the nature of the products of the explosion of Gun-cotton have a similar influence upon the change which gunpowder may be made to undergo; and that, *secondly*, the effect of heat upon the water produced by decomposition of Gun-cotton, which forms so important an element in the action of this explosive, has most probably its parallel, to no unimportant extent, in the vapourizing effect of heat upon the solids (especially upon sulphide of potassium) produced in the explosion of gunpowder. These are matters which demand their full share of consideration and investigation, before it can be admitted that a sufficient explanation of the remarkable differences between the effects of gunpowder and Gun-cotton exists in the assumption, that certain products of decomposition of the former must be regarded entirely as waste matter in the material, simply because they are solid *at ordinary temperatures.* The fact, that Gun-cotton is *entirely* converted into gases and vapour *at the moment of explosion*, constitutes unquestionably one of the great advantages which that substance possesses over gunpowder; but it is premature, at present, to assume, in comparing the action of the two substances, that only thirty-two (or even sixty) per cent. of gunpowder exist as gas or vapour, *at the moment of its explosion.*

It is to be expected that the investigations which are now being actively pursued upon the true chemical effects produced in the explosion both of Gun-cotton and Gunpowder, under conditions similar to those which attend their employment in practice, will aid materially in furnishing the correct data so essential for a thorough and impartial comparison of the nature and merits of these two explosive agents.

[F. A. A.]

WEEKLY EVENING MEETING,

Friday, April 22, 1864.

COLONEL SIR GEORGE EVEREST, C.B. F.R.S. in the Chair.

PROFESSOR JOHN S. BLACKIE, M.A.

OF THE UNIVERSITY OF EDINBURGH.

On the Spartan Constitution and the Agrarian Laws of Lycurgus.

THE peculiar institutions and laws which go under the name of Lycurgus—in some respects a wonder and a problem to the ancients themselves—have in recent times received a very full and detailed discussion from some of the most distinguished scholars of Germany and England. Foremost among these, of course, is to be mentioned Ottfried Müller, in his great work on the Dorians; then, particularly, the historico-archæological disquisitions of C. F. Hermann and Schœmann; with the admirable summing-up the results of these investigations in the historical works of Curtius and Duncker. In our own country, after the solid and substantial substructure of Thirlwall, ground was broken by Dr. Arnold in one of the notes to his Thucydides, and the views there set forth were carefully sifted, and the whole question stated with complete originality and independence by the late Sir George C. Lewis in an essay in the Cambridge Philological Museum. After this, Mr. Grote, in the second volume of his great

Gun-cotton, upon the relation between the *quantity* as well as the *degree* of heat applied and the amount of surface of the Gun-cotton, and upon other conditions. While a small spark, or a thin platinum wire heated to full redness, only induces slow combustion in the compact Gun-cotton yarn, a thick rod of iron, heated only to dull redness, will invariably inflame it in the ordinary manner. A piece of open yarn cannot be ignited so as to burn in the slow manner; on the other hand, the more compactly the Gun-cotton is twisted, the more superficial is the slow form of combustion induced in it; indeed, the Gun-cotton may be rendered so compact that it will simply smoulder in open air, if ignited as described, leaving a considerable carbonaceous residue; and the heat resulting from this most imperfect combustion will sometimes be abstracted by the escaping gases more rapidly than it is developed, so that the Gun-cotton will then actually cease to burn, even in open air, after a short time.

The remarkable facility with which the effect of heat upon Gun-cotton may be modified, so as even to produce results totally opposite in their characters, as exemplified by some of the experiments which have been described, renders it easily conceivable that this material may be made to produce the most varied mechanical effects, when applied to practical purposes; that it may indeed be so applied as, on the one hand, to develope a force, very gradual in its action, which may be directed and controlled at least as readily as that obtained by the explosion of gunpowder, while, on the other hand, it may be made to exert a violence of action and a destructive effect far surpassing those of which gunpowder is susceptible. The results arrived at in Austria, which show that Gun-cotton may be made to produce effects from three to eight times greater than those of gunpowder, cease to be surprising after a study of the chemical and physical characteristics of this interesting explosive agent.

The products obtained by the explosion of Gun-cotton, and its decomposition under various conditions, have as yet been very imperfectly studied, but there is little doubt that they vary in their nature almost as greatly as the phenomena which attend the exposure of the material to heat under different circumstances. It is well known that, when Gun-cotton is inflamed in the open air, there is produced (in addition to water, carbonic oxide, carbonic acid, and nitrogen) a considerable proportion of binoxide of nitrogen, so that the gaseous mixture assumes a red-brown tinge, and becomes very acid when it mixes with air. The products of the different forms of imperfect combustion which Gun-cotton has been described as susceptible of undergoing, are undoubtedly much more complex in their character than those just referred to. They include at times a proportion of some substances, not yet examined, which make their appearance as a white vapour or smoke; cyanogen can readily be detected in all the products of imperfect combustion; the proportion of binoxide of nitrogen is generally so large that the gaseous product becomes very highly coloured when mixed with air; peroxide of nitrogen has also

far as the rights of citizenship were concerned—were wont to meet
the management of public affairs in two bodies: the one general-
led ἐκκλησία, of which the members, though select as respects the
ole population, might be called a [illegible] or [illegible] as respects the
re select body chosen out of their members: the other the [illegible],
senate of elders, an elective body chosen by the general mass from
members of their own body, of the greatest social weight and
uence, being not less than sixty years of age. This [illegible] may
t be regarded as a standing committee of the privileged classes,
stantly renovated from the general mass by a law of merit and
iority, and entrusted with the exclusive right of discussing all
portant public questions, and proposing all legislative measures in
e first place. In this body, therefore,—as any person practically
quainted with the working of political machinery will at once divine
-lay the real power of the government in Lacedaemon, at least when
e constitution acted normally, and was not disturbed, as it was
able to be, either by the arbitrary power of the ephors—of whom
non—or by the preponderant personality of an energetic monarch.
As for the larger assembly—the ἐκκλησία, though by the theory of the
onstitution possessing the supreme power in the last resort—exactly
fter the Homeric type, so familiarly known from the opening scene in
liad II.—yet it played a very subordinate part in Spartan politics,
nd makes little figure in Greek history, manifestly because its interests
nd feelings were represented by its own best members, who regularly
assed into the γερουσία at the very age when their weight as public
ounsellors had reached its acme. An opposition between the two
ivisions of the Spartan privileged class, such as exists in our country
etween the house of commons and the house of lords, never did
xist, and never could exist: because the Spartan lower-house was [illegible]
ct a house of nobles, and the upper-house was only a select standing-
ommittee of the lower-house. Anything, therefore, like popular or
emocratic assemblies, in our sense of the word, anything like active
arties within the mass of the governing body, anything in the shape of
pular measures, popular eloquence, and champions of popular
ghts, was altogether unknown in Sparta. In this regard Professor
rtius does not overstate the matter when he says that 'though
Spartan people had no laws or public measures of any kind forced
n them without their concurrence, yet as a rule they did not
ern; they were governed.' For this reason, in the annals of their
lic life we hear of no Olympian Pericles, no brilliant [illegible], no
etuous Demades, no terrible Demosthenes, but [illegible] a [illegible] and
shed, well-balanced, well-[illegible], well-[illegible], well-[illegible], well-
shed, and altogether well-[illegible] Lacedaemon. They had no political
ature.

The ephors, who, like the Roman tribunes, from small beginnings
to a power that often overshadowed the kings and even over-
e the senate, have a very mysterious aspect to the student who
t begins to look into the details of the Spartan government

historical work, propounded his views on the Spartan institutions generally, with great originality and boldness, and specially on the famous Agrarian laws. After such labours of such men, it seems not unreasonable to think that we should have now arrived at some certain and indisputable conclusions, on which those who read Aristotle, Isocrates, and Xenophon some two hundred years ago, could only have very misty apprehensions. It is the intention of this discourse, accordingly, shortly to review the results which, in this most interesting field of archæological research, we seem to have arrived at; and in doing so the method which I shall adopt is to state shortly, in the first place, the undisputed points in reference to the Spartan Constitution—that is, such points as all well-instructed scholars, being men of sound judgment, and not hunters after novelty, are now agreed on; and in the second place, to discuss in detail one of the most characteristic of the Spartan institutions, which is still lying under the severe ordeal of Mr. Grote's sceptical reprobation, and which, therefore, cannot be considered as undisputed among European scholars.

Among the undisputed points I notice the following:

1. The political constitution of Sparta was a broad aristocracy, limited to some extent by regal rights and usages, but in no degree modified by popular influence in the modern, or even in the Roman or Athenian, sense of that term. By a *broad* aristocracy, I mean a large corporation of privileged proprietors, varying from 10,000 to 2,000, with a monopoly of political power, exercised indeed by different individuals in different degrees, but altogether exclusive of the great mass of the population, who were politically null, as much, or rather a great deal more than the unenfranchised class in this country, because they were in no sense recognized as members of the body politic, were never appealed to even in the most distant way, and had no influence of any kind in public affairs. This broad aristocracy was, in fact, the whole Spartan people, who, as Dr. Arnold properly expressed it, were "a nation of nobles,"—a brotherhood of privileged warriors, permanently encamped in a country whose native population they treated as a nullity, as much as the laity is ignored by the clergy of the Romish Church. The only limitation to which the great power of this aristocracy was subject, is found in the influence of the kings: and this, connected as it was with the great element of religion, and the important functions of war, must, when assisted by the weight of personal character, have often been considerable. Nevertheless, monarchy in Lacedæmon, weakened as it was by the general strength and breadth of the aristocracy, and also by the early splitting of the undivided Homeric kingship into two—itself the strongest proof of the great strength of the old aristocracy—never could have been in a position to stamp a permanently distinctive character on the constitution. Its proper type always was aristocracy: a "close, unscrupulous, and well-obeyed oligarchy" according to Mr. Grote, if any person prefers that phraseology.

2. The Spartan privileged class—that is, the whole Spartan people.

so far as the rights of citizenship were concerned—were wont to meet for the management of public affairs in two bodies: the one general, called ἐκκλησία, of which the members, though select as respects the whole population, might be called a δῆμος or πλῆθος, as respects the more select body chosen out of their members; the other the γερουσία, or senate of elders, an elective body chosen by the general mass from the members of their own body, of the greatest social weight and influence, being not less than sixty years of age. This γερουσία may must be regarded as a standing committee of the privileged classes, constantly renovated from the general mass by a law of merit and seniority, and entrusted with the exclusive right of discussing all important public questions, and proposing all legislative measures in the first place. In this body, therefore,—as any person practically acquainted with the working of political machinery will at once divine—lay the real power of the government in Lacedæmon: at least when the constitution acted normally, and was not disturbed, as it was liable to be, either by the arbitrary power of the ephors—of which anon—or by the preponderant personality of an energetic monarch. As for the larger assembly - the ἐκκλησία, though by the theory of the constitution possessing the supreme power in the last resort—exactly after the Homeric type, so familiarly known from the amusing scene in Iliad II.—yet it played a very subordinate part in Spartan politics, and makes little figure in Greek history, manifestly because its interests and feelings were represented by its own best members, who regularly passed into the γερουσία at the very age when their weight as public counsellors had reached its acme. An opposition between the two divisions of the Spartan privileged class, such as exists in our country between the house of commons and the house of lords, never did exist, and never could exist; because the Spartan lower-house was in fact a house of nobles, and the upper-house was only a select standing-committee of the lower-house. Anything, therefore, like popular or democratic assemblies, in our sense of the word, anything like hostile parties within the mass of the governing body, anything in the shape of popular measures, popular eloquence, and champions of popular rights, was altogether unknown in Sparta. In this regard, Professor Curtius does not overstate the matter when he says that, "though the Spartan people had no laws or public measures of any kind thrust upon them without their concurrence, yet, as a rule, they did not govern; they were governed." For this reason, in the annals of their public life we hear of no Olympian Pericles, no brilliant Alcibiades, no impetuous Demades, no terrible Demosthenes, not even a correct and polished, well-balanced, well-washed, well-anointed, well-combed, well-brushed, and altogether well-bred Isocrates. They had no political literature.

The ephors, who, like the Roman tribunes, from small beginnings rose to a power that often overshadowed the kings, and even over-rode the senate, have a very mysterious aspect to the student who first begins to look into the details of the Spartan government machine. But, on a little consideration, now that all the available evidence has been carefully collected, it appears to me that there cannot be the slightest doubt as to the true origin of the extraordinary authority which, at certain periods, they exercised in public affairs. The ephoralty arose from the necessity of providing a field for the energies of ambitious and adventurous young Spartans in the time of peace. The law that no person should become a senator till the ripe and safe age of sixty, was for purposes of aristocratic conservation unquestionably a very wise one. But even in the most firmly-compacted aristocracies there are combustible and explosive elements which must be provided for; and these elements exist nowhere so strong as in the hearts of young men of talent and energy. Now, in our country, the house of commons presents exactly the sort of arena which is best adapted at once to gratify the ambition and test the capacity of such active spirits. But in Sparta, as we have seen, the *ἐκκλησία* could perform no such functions; therefore, instead of public speaking and parliamentary tactics, a sort of overseership and censorship—first in smaller, and then gradually extending to more important matters—was laid open to the adventurous and ambitious among the young Spartans, in which field of executive activity they might blow off their dangerous steam in time of peace, and feel that they wielded a power in certain matters which not even the king or the senate could treat with contempt. A free career being thus laid open to the young men and the less influential aristocracy, the *ἐκκλησία* was in all respects qualified to play that acquiescent and innocent part which it played in Spartan history. It became, in fact, politically null; not because it had no rights, but because there was no need for exercising its rights. In this way it came about that Sparta, for the space of four hundred years, exhibited to wondering Greece the most notable example of a stable conservative government, without any disturbing opposition, that ancient history knew. In fact, with such a perfectly satisfied broad aristocracy, if there was at any time any opposition to the government, it arose either in the shape of absolute mutiny and revolt among the helots, and unrecognized subject-classes, or in the shape of conspiracy amongst some of the Spartans proper, who had lost their franchise by default, that is, either by not having conformed to the social regulations of Lycurgus, or by not possessing the necessary property qualification, and who were therefore no longer ὅμοιοι—peers among peers. Of such a conspiracy we have a well-known example in the case of Cinadon, which took place at the commencement of the reign of Agesilaus, B.C. 398. The proceedings connected with the quashing of these mutinies and conspiracies reveal to us the weak point of the Spartan government. A numerous subject-population, absolutely without political rights, can be governed only by fear, and is kept in check, partly by that unity of counsel and action which belongs to all well-organized governing bodies, partly by a system of secret police, and secret execution, in that arbitrary form which is always the plague-spot of the government which employs it, and which, in the

Sparta, was distinguished by acts of bold unscrupulousness
·blooded atrocity, surpassed by nothing that modern records
n the annals of Rome, Naples, Paris, or Madrid.

he whole, therefore, we see, that notwithstanding the confes-
neficial effect of the severe physical and moral training to
e young Spartans were subjected, the results of their political
ere not such as to present a purely aristocratic government in
larly attractive light. The Spartan system made good sol-
lled and maintained in notable efficiency, a small people of
d proprietors supported by their swords; but it altogether
produce a great people. In external form only, to the super-
, the Spartan constitution exhibits that mixed form of govern-
mposed of the three necessary elements of king, lords, and
, which the wisest of the ancients looked on as the best pos-
'ernment; but there was, in reality, no people, no liberty, no
it, and no enterprise. What we find instead of a great, strong,
happy people, is a very manly and vigorous, severely-trained,
iplined, and thoroughly effective aristocracy; but an aristo-
ogether unfit to go beyond the narrow territorial limits within
grew up, and no more qualified to produce the highest type
ited humanity, than the institutions of Plato's paper republic,
tape and pipe-clay ordinances of Berlin bureaucracy, or the
exercises of a Jesuits' College in Madrid or Rome.

uch seems undisputed. I shall now notice two points of con-
importance in the Spartan political and social organization,
nsidering the weighty names who have advocated opposite
regard to them, must be looked on as yet *sub judice* in the
learned research. The first of these points relates to the true
d character of those Spartans who were called *ὅμοιοι*, *Equals*
. With regard to these, the late Sir G. C. Lewis, in the
gical Review' (vol. ii. p. 64), has advanced a theory that they
ll probability "an aristocratical class within the body of the
who were much employed in public offices, and had great in-
rith the government, originally, perhaps, selected for their
nd afterwards their rank became hereditary." This theory
controverted by Professor Schœmann, in an able paper in his
s *Academica:* and without going into the detail of the argu-
shall only here state generally, that the passages in which
is made of these *ὅμοιοι* in the Greek classics, are few and
l, and that, after a careful examination of them all, I have
the conclusion that there is no sufficient ground in the existing
es for the theory advanced by the learned English statesman:
if we take the evidence as we have it, without adding to it in
of conjecture, we must just simply say that the *peers* were all
tans who had not lost their property or other qualification.
, indeed, and a sort of democracy within themselves, was an
characteristic of society in Sparta—*ἰσονομία* and *δημοκρατία*
ri in the very words of Isocrates (Panath. 270 c.); and the

formation of a class of superior hereditary privileged peers, in our sense of the word, is not to be assumed without the strongest reasons, in the face of the plain presumptions to the contrary, arising out of the whole constitution of oligarchy in Sparta.

But the most important of the disputed points of the Spartan social organization is that which relates to the AGRARIAN LAWS. On this subject the great English historian of Greece, Mr. Grote, has lately advanced a theory, which, as it runs counter not only to all the ancient authorities, but to the weight of learned opinion in Germany, well deserves the serious consideration of English scholars; the more so that, so far as I can see, the weight justly due to that learned gentleman's authority has had a tendency to procure a ready admission to certain brilliant sceptical novelties, enunciated by him, in quarters where a decided opposition, on strong conservative principles, was rather to have been expected; and thus the student of ancient history comes suddenly upon the somewhat singular phenomenon, that on one point at least of Hellenic research, while such Teutonic excavators as Ottfried Müller, C. T. Hermann, Schœmann, Curtius, and Düncker are marshalled on the side of ancient tradition and authority, in Oxford a learned professor of ancient history* can declare that Mr. Grote has proved, with "irresistible force," that all we have hitherto been taught of Agrarian laws in ancient Sparta is a hallucination and a dream. The two nations thus appear to be changing sides; the compatriots of Niebuhr have become historical conservatives, while the countrymen of Clinton seem eager to blow away early history into symbolism and myth. The mere suddenness and completeness of this rebound might seem to indicate that the matter had not been duly sifted, and that Mr. Grote's theory has been received more from the weight due to his authority, than from an impartial consideration of the evidence. So at least it appears to me; and it shall be my object in what remains of this discourse to state in detail the real significance of the ancient authorities on the subject, and how far they are from giving any countenance to the ingenious, but, in my opinion, baseless theory of Mr. Grote. Let it be noted, however, that when I speak of Agrarian laws as an integral part of the Lycurgean organization, I do not mean to assert that the legislator introduced these laws for the first time any more than he introduced the kingship or the senate. It belongs to God to create; the highest of mortal legislators can only use existing materials. All I say is, that, on a due consideration of all the ancient authorities, which are our only safe guides in this matter, Agrarian laws must be acknowledged as, from the earliest times, part and parcel of that singular social organization which bore the name of Lycurgus. In Lycurgus, as a man and a lawgiver, and not as a myth, a symbol, or an indefinite somebody or anybody, for reasons that I cannot here state at length, I most potently believe; but I am not in the slightest degree concerned to tain that all the characteristic Spartan laws and customs on which ame was stamped, really proceeded originally from him ; much hat we are bound to accept, as his actual scheme, every minute l of his legislation as presented to us in the highly-finished, or as ight say, cunningly-cooked, accounts of late historians.

---

* Rawlinson's Herodotus, vol. iii.

et us now examine Mr. Grote's position. His denial of the tan Agrarian laws, as an historical fact, proceeds mainly on the tion, that while these laws are either ignored or contradicted by all arlier and more trustworthy witnesses, they are asserted only by r two recent and less creditable authorities. This statement of ase is certainly very plausible. It is pretty much as if he had all the eye-witnesses knew nothing about the matter in question, hearsay asserts it. But the nature of the existing authorities not allow us to dispose of the question in this way. There are ye-witnesses in the case: the oldest cited, *viz.* Plato, lived at four hundred years after the great Spartan lawgiver ; and in such mstances mere priority in point of date is not of itself sufficient to eigh other and more material considerations. Nay, even in a ion question of legal evidence, as every lawyer knows, the mere ess of a witness to the time in which a disputed fact took place, ot of itself be able to secure to his testimony any peculiar prece. I shall, therefore, adopt what appears to me the more true od of stating the evidence in an historical question of this kind. I first cite those authors who give a distinct and deliberate testi- to the Spartan Agrarian laws, and then inquire how far their nce is contradicted by any testimony to the contrary. In the place, we have Polybius, a Greek, a native of the Peloponnesus, iving in the times immediately following the Agrarian agitations e famous Spartan kings, Agis and Cleomenes. Of his weight and nent in political matters no one ever expressed a doubt ; and his nony to the existence of equal allotments of land in Sparta, as f the most characteristic elements of the Lycurgean legislation, is in a passage (vi. 45.) where he expressly discusses political conions, and draws a direct contrast between the Cretan and Spartan ns on this very point. A more valuable witness, therefore, on a matter, could not be cited. Then we have Plutarch, in his of Lycurgus, — an author whom it is easy to call an "old " but who, in fact, was one of the best-read men of his day, a man of remarkable good sense and sound judgment. No t he tells many stories which, like all historical anecdotes, may been improved in the telling, or even invented to illustrate lar opinion : unquestionably also, his philosophy of history, exhig the whole Spartan constitution as jumping ready-made out of rain of Lycurgus, is far from profound ; but it remains to be d that he has ever given false representations of great historical cters, or lightly stated any important historical fact. On the ary, I feel convinced, that before he sat down to write his life of rgus, he had read Aristotle's famous work περὶ πολιτειῶ nor lost; and that the very distinct evidence given by him as to the Spartan Agrarian laws, must be regarded not as his testimony merely, but *as the result of the whole mass of historical evidence, including, of course, Aristotle, which he had consulted on the subject.* And here we must observe, that in talking of the Spartan Agrarian laws, we are dealing with a matter, which, if it was not a mere figment, as Mr. Grote will have it, must have been as well known in ancient Greece as it is in modern Europe, that the government of the Romish church is monarchical, and that the principle of ecclesiastical democracy is represented by the Presbyterians in Scotland. Facts of this kind are far too deep-fixed in their roots, and far too wide-spread in their branches, to be either invented or ignored. If they are invented, they will not be believed; if they are believed, it is because they cannot be ignored. To me, therefore, the testimony of two such writers as Polybius and Plutarch, expressly handling the subject, and summing up as they do the whole historical tradition of antiquity, are quite sufficient to establish the existence of Agrarian laws in ancient Sparta, although they were not supported by any other evidence. But this is far from being the case. Isocrates, in his Panathenaic oration, where a contrast is distinctly drawn between Athenian and Lacedæmonian institutions, talks expressly (270 c.) of the equality of lots in land, which characterized the Dorians when they first settled in the Peloponnesus, *τῆς χώρας ἧς προσήκει ἴσον ἔχειν ἕκαστον*: and Plato, in the third book of his laws (684 d.) manifestly alludes to the same state of things. I conceive, therefore, that we have the concurrent testimony of historians, orators, and philosophers, asserting or implying the state of things in reference to the distribution of land in Sparta, which Mr. Grote, with such "irresistible force," is said to have disproved. What, then, are the authorities by which we are called on to consider that he has successfully rebutted the weight of the positive evidence just adduced? His great authority, manifestly, more narrowly looked at, in fact, his only authority, is Aristotle—a name heavy enough, perhaps, to outweigh all others, if only it shall turn out that, in the present case, his evidence has been duly sifted and justly weighed. But how stands the fact? The great philosopher's great book *Περὶ Πολιτειῶν* on "political constitutions," which, as a matter of course, contained a detailed account of Spartan laws and customs, exists, as we have already stated, no more: and we have only his work on the theory of politics, in which some points of the Spartan polity are incidentally discussed. These discussions occur principally in the Second Book; and it is here that Mr. Grote finds a notable passage (ii. 6) asserting not the equality, but the extraordinary and abnormal inequality, of property in the Spartan territory. Now, in order to understand this, we must consider carefully the whole plan and scope of the book on Politics, and interpret the Second Book with reference to that plan. The work is purely a theoretical investigation, with the view of discovering the *ἀρίστη πολιτεία*, or what we call the "ideal commonwealth:" and in order to give a proper starting-point for such

restigation, the philosopher has to prove in the first place that no
epublic already exists either in theory or fact: that the intellec-
rojections of Plato and the realized work of Lycurgus are equally
lt; and therefore that the speculations of the philosopher are not
osed; he may safely go on reasoning out the scheme of a best
, without being liable to the charge of *actum agere*. This cha-
of the Second Book sufficiently explains its somewhat ungracious
de, that of systematic fault-finding. He has merely to show that
arious constitutions which he passes under review have, as a
r of fact, proved to be failures in certain points; and his case is
out. Accordingly, to use a vulgar phrase, he sets himself,
he does with manifest gusto as an Athenian, to pick holes in the
of Lycurgus; and has no difficulty in finding, that the Spartan
n, so often celebrated for their patriotism and their domestic
s, are in fact the most extravagant, the most blushless, and the
domineering ladies in Greece; and that the lands, instead of being
divided, are accumulated in the hands of a very few proprietors
h accumulation all the ancient philosophers looked on as a great
evil), and these proprietors principally women. And in account-
r this abnormal state of things, he goes on to accuse the legis-
of inconsistency, in having allowed the free disposal of landed
rty by testament, while he forbade it by sale *inter vivos*. Now
hole way of stating the matter, not only does not seem to me to
but rather plainly to imply, the existence of an equal division of
l property in the early days of the Spartan ascendancy. The
rite speaks in this whole book of what Sparta had become in his
ot of what it was in the days of Lycurgus. He did not require
his readers what everybody knew, that since the days of Lysan-
Sparta was no more what it had been under Lycurgus, than
Solomon of Palestine was like Joshua or Gideon. Whatever
gus might have wished to make of Lacedæmon, he had not achieved
e boasted Spartan constitution, which Plato and Xenophon had
l, was a manifest failure: and whoever felt inclined to set up
s a model of the ἀρίστη πολιτεία was contradicted by the strong
g fact, worth a whole waggon of arguments.

he evidence of Aristotle being thus disposed of, Mr. Grote's case
authorities, according to my judgment, completely breaks down.
ther witnesses whom he cites, either say nothing at all on the
or say something quite different from what Mr. Grote supposes.
there occurs occasional mention of rich men in Sparta, as well
ewhere, is nothing to the purpose. The Spartan magnates, in
ys of Herodotus and Thucydides, might have acquired wealth
ious ways, altogether independently of the original equality of
nded lots, on which the exercise of the rights of citizenship
led. The mere silence of Herodotus in a passage (lib. i.),
he is only mentioning Lycurgus in the most incidental way, can
no weight; and the defects in the slight treatise of Xenophon
manifest, that any mere omissions can prove nothing. The

testimony of Isocrates in another passage of the oration already quo (287–6), has not the slightest bearing on the question ; for there orator is talking not of the original tenure of landed property un the Lycurgean institutions, but of the freedom of Sparta, during long course of four hundred years, from violent Agrarian revoluti and other social convulsions—a freedom to be attributed principal after the general conservative character of the government, to t original equality in the division of property which rendered fut Agrarian agitation unnecessary.

If these observations are correct, the result of our examinati manifestly is, that there is no historical evidence whatever against t Spartan Agrarian laws ; and if Mr. Grote's sceptical rejection is to accepted, it must be based on grounds of internal improbability, whi render all external assertion superfluous. It remains now that we lo at the matter shortly from this point of view.

Agrarian laws have not been fashionable in modern times—least all in Great Britain. They are contrary to our British instinct individual liberty, and our national habit of leaving no more pow than is absolutely necessary in the hands of the central governme We are apt to look upon them, consequently, as either ideal or rev lutionary ; but though some valuable discoveries have been made history since the time of Niebuhr, by interpreting the past through t present, nothing could lead to greater mistakes in the philosophy ancient social life, than the supposition that it was in all respects li our own. On the contrary, it is certain that in many respects it w as much as possible unlike. It is in the contrasts, not in the identiti which ancient history presents, that great part both of its charm, and its instructive virtue, consists. The ancient Dalmatians, we are told Strabo (vii. 315), made a general re-division of their lands every eigh year. Are we to disbelieve this, merely because such an agrarian c tom appears to us altogether preposterous, unjust, and impolitic? so, we must take up David Hume's position, and believe nothing, ho ever well attested, that is contrary to the results of that very undefin range of induction which we call our experience. We shall, therefo say that there is nothing improbable in the idea that an ancient leg lator may have assigned his citizens equal lots of land, however mu such a measure may be contrary to English instincts and modern pra tices. And if we look at the real position of the Dorians as a co paratively small body of invaders encamped in a hostile country whi they held in subjugation, we shall see the strongest argument in favo of the existence of an Agrarian law such as was popularly attribut to Lycurgus. An uncontradicted tradition asserts that after conquest the Peloponnesus, the position of the Dorians was for a considerabl period extremely uncomfortable. They had the utmost difficulty in hol ing their ground. Now, in such circumstances, nothing could be mo dangerous to the common cause than those feuds and jealousies among themselves which are wont to arise from an unequal distribution o property. As a nation of warriors, who had acquired this new terri tory by the sword, they had been exposed to common perils, and were entitled to a common reward. But against this law of equal national right to the conquered territory, the cupidity and violence of individual chiefs would no doubt prevail; and the discontent hereby caused would breed exactly that state of public danger, in which the safety of all would be consulted by giving an unlimited power of arbitration to some influential person on whom all could rely. Such a national arbiter in matters between debtor and creditor, within the strictly historical period, was Solon, in Athens; such an arbiter, specially in reference to landed property, I conceive Lycurgus to have been when he is spoken of as the author of the Agrarian laws. I do not by any means think myself bound to inquire into the probable correctness of the details of these laws as given by Plutarch; but the fact itself carries with it all the probability that the existing circumstances, the habits of thought of the ancient mind (Müller, Dor. ii. p. 212, English), and the analogy of certain well-known facts in modern history can confer. The secularization of church lands at the French revolution, and the law of succession to landed property then established, operated practically as an Agrarian law, tending both to prevent immense accumulations of property in the hands of individuals, and to create among the newly-constituted proprietors, a broad, permanent interest in the new state of things. An Agrarian law of a different kind was that carried out by Baron Stein in Prussia, under the pressure of the great national humiliation subsequent to the battle of Jena in 1808. On the whole, I am so far from seeing any improbability in the alleged equality of lots, which, according to the universal testimony of the ancients, characterized the Spartan public economy, that it appears to me to be only a necessary part of their general system of equality and brotherhood, within certain well-known and narrowly-drawn limits of aristocratic privilege. Among a race of proprietors as unequal as the present English nobility and gentry, a common mess, the *συσσίτιον*, so characteristic of Spartan life, would have been an impossibility.

With these convictions, I need hardly say that I see no need for having recourse to that "new canon of historical criticism" which Mr. Grote (vol. ii. p. 165, edit. 1862) brings upon the stage for the sake of solving the difficulties connected with the alleged Agrarian law of Lycurgus. This canon, which traces the belief in this law to the heated enthusiasm of certain interested dreamers in the days of Agis IV. and Cleomenes (250 and 222 B.C.), appears to me merely a special application of the thaumaturgic German fashion of creating history out of conjectures, against which I think our British instinct ought to lead us distinctly to protest. The habit of dealing negatively with old national tradition and supplanting it by plausible theories, is always flattering to the ingenuity of scholars, but affords a very questionable basis for anything that can be called history. For myself I do not believe that a royal reformer such as Agis, wishing to move the people to an acceptance of a great measure of Agrarian reform, could

do so by appealing to a mere figment, the child of yesterday's d
but his only hope of success must lie in his being able to clo
startling aspect of his revolutionary measure with all the attr
that belong to the re-brightening of a faded memory deeply sea
the traditional consciousness of the people. Generally speaking,
I would willingly admit that the outer links and flourishes of n
tradition are often invented, I do most firmly believe the tru
body of any deep-rooted, widely-spread popular belief to be a
material fact in the outward fates of the nation; as the soul of
moral fact, often the most important moral fact in the history of
people. Such facts were the battles of Bannockburn and Drumc
Scotland; the Norman conquest in England; the legislation of
among the Hebrews, and of Lycurgus among the Spartans; the
time sway of Minos in the isles of the Ægean, and the brillia
potism of the Tarquins in early Rome. Facts of this nature, as
personalities to which they are bound, possess a tenacious vitality
continued consciousness of a nation, altogether independent o
scrolls of written record by means of which their reality may have
externally attested.

[J. S.

WEEKLY EVENING MEETING,

Friday, April 29, 1864.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-Presid
in the Chair.

Professor Alexander W. Williamson, F.R.S.
President of the Chemical Society, &c.

On the Classification of the Elements in relation to their Atomicities.

The speaker proposed to bring under the consideration of the memb
some of the chemical grounds for doubling the atomic weights of
the metals in Gerhardt's system of atomic weights, excepting the al
metals, silver, gold, boron, and the metals of the nitrogen series.
change which has been proposed mainly on physical grounds

izzaro, and which seems to be obtaining the approbation of more ore chemists.

TABLES OF ATOMIC WEIGHTS.

Class of Elements, which only furnishes an even number of to each Molecule:—

Fl	= 19	H	= 1	N	= 14
Cl	35·5	Li	= 7	P	31
Br	80	Na	= 23	As	75
J	127	K	= 39	Sb	122
		Rb	= 85	Bi	210
		Cs	133	B	11
		Tl	203	Au	196
		Ag	108		

d Class of Elements, which sometimes furnishes an odd, some- an even number of atoms to one Molecule:—

O	= 16	C	= 12	G	= 9
S	= 32	Si	28	Yt	64
Se	79·5	Ti	50	Ce	92
Te	129	Sn	118	La	92
Ca	40	Mo	96	Dy	96
Sr	87·5	V	137	U	120
Ba	137	W	184	Zr	89·5
Pb	207	Pt	197	Ta	138
Mg	24	Tr	= 197	Cb	195
Zn	65	Os	199	Th	238
Cd	= 112	Ro	104		
Hg	200	Ru	104		
Al	27·5	Pd	106·5		
Fe	56				
Cr	52·5				
Mn	55				
Co	58·5				
Ni	58·5				
Cu	63·5				

is now about twenty years since Gerhardt drew attention to the of the molecular weights, or equivalent weights, as he called , which represented water as consisting of one atom of oxygen ne of hydrogen, and proposed to double the atomic weights of n and of carbon.

Gerhardt had taken Berzelius's atomic weights and, while trans- them into the hydrogen scale, had halved the atomic weights of kali metals and boron, he would have given us at once the system we now adopt, saving the rectification of a few formulæ, such as that of silver and oxide of uranium, &c.; whereas by merely doubling oxygen, sulphur, selenium, and carbon, in the then existing system of atomic weights in the hydrogen scale, he really introduced a system in which there are between 30 and 40 atomic weights to correct, in lieu of one which needed only five or six such corrections. It would be unreasonable to apply this fact in any degree to the disparagement of Gerhardt's work. It only shows how tortuous is the road which leads to truth.

The discussion of the question involves chiefly the consideration of the classification of the elements under the respective heads of chlorine and of oxygen.

The first tribe containing those elements of which an atom combines with one atom of hydrogen or chlorine, or with three or with five, &c., whilst the second tribe contains elements of which each atom combines with two atoms of chlorine, or other monads, or with four, or six, &c. The speaker did not, however, recommend that the two great classes of elements be thus distinguished from one another, for our chief evidence of atomic weights is derived from the study of the molecular weights of compounds, and the molecule is the unit to which results must be referred.

The first class is best described as furnishing only an even number of atoms to each molecule, whereas the second class sometimes furnishes an even, sometimes an uneven number of atoms to one molecule. The process of classifying the elements has followed the very natural order of establishing a certain number of well-defined families, which were subsequently connected together by erratic members, which occasionally left their usual place to go over to some neighbouring family. Chlorine, bromine, and iodine have long been acknowledged to constitute a natural family; and there are some, though hardly sufficient reasons for placing fluorine at its head. The three elements have the same vapour volume as hydrogen in the free state, and we accordingly represent their respective molecules as Cl^2, Br^2, I^2, corresponding to $H^2 = 2$ vols. They form hydrides of similar composition, and analogous properties, and of the same vapour volume. Their compounds with most metals are analogous and have the same atomic heat and general crystalline form. Their corresponding oxygen acids also exhibit considerable analogy.

With organic radicals they form neutral ethers, like $Cl\,C^2H^5$, $Cl\,C^2H^3O$, and no acid ethers. So that when a molecule of alcohol or of acetic acid is replaced by chlorine, two atoms of chlorine take the place of one atom of oxygen, and give rise to a molecule of chloride of ethyle and a molecule of hydrochloric acid. They replace hydrogen atom for atom, taking out one, two, or three atoms, &c., according to circumstances. Their hydrogen compounds are all monobasic acids; for if, in a given quantity of hydrochloric or hydrobromic or hydriodic acid, we replace part only of the hydrogen by potassium, we get at once a neutral salt mixed with the remaining acid, which is undecomposed, and never an acid salt of the alkalies. Fluorine in this respect exhibits an anomaly which tends to remove it from this family to a biatomic one. For the acid fluoride of potassium is a well-defined compound of considerable stability, of which the existence points to the atomic weight 38 for fluorine, and the formula H^2F for hydrofluoric acid. Hydrofluoric acid, moreover, combines with various metallic fluorides—such as fluoride of silicon and fluoride of boron; and there are double fluorides of aluminium, &c., with alkaline fluorides, both well known and easily formed.

Similar double salts are, however, formed by chlorine; for instance, terchloride of gold combines with a molecule of hydrochloric acid, or of an alkaline chloride. Tetrachloride of platinum combines with two molecules of hydrochloric acid or of chloride of potassium, &c.

It is not possible to reconcile the constitution of these and similar bodies with one another and with the simpler compounds of chlorine, by any theory representing it as polyatomic, and as holding together the metallic atoms in these salts in virtue of its polyatomic character. On the other hand, hydrochloric acid and metallic chlorides of opposite properties cannot be assumed to be incapable of uniting with one another, while it is well known that oxides of basylous properties unite with those of chlorous properties. Hydrochloric acid unites with ammonia, and we do admit that the two molecules are bound together into one by a chemical force of combination, and not by any tetratomic character of the hydrogen; and HCl or KCl combines with SO^3 by a similar force.

Again: oxygen, sulphur, selenium, and tellurium are admitted to be truly analogous elements, for the parallelism of oxygen salts, and sulphur salts, affords abundant proof of the analogy of oxygen and sulphur, and the molecular volume of sulphur and selenium is found by Deville to agree at high temperatures with that of oxygen.

The elements selenium and tellurium form acids analogous to sulphurous and sulphuric acids respectively. When combined with organic radicals they form compounds of the same molecular volume in the form of vapour; and when any of them, such as oxygen, replaces hydrogen in an organic body, it takes out two atoms of hydrogen at a time, replacing each couple by one atom of oxygen, as in the formation of acetic acid from alcohol.

When we partially decompose water by potassium we get hydrate of potash formed, which is a molecule of water, from which half the hydrogen is expelled and replaced by potassium, and a second atom of potassium is required to displace the remaining hydrogen.

If we compare any proto-chloride with a corresponding oxide, either of a metal or organic radical, we find that the molecule of the oxide contains twice as many atoms of the metal or radical as the chloride, and that one atom from the oxygen family is equivalent to two atoms from the chlorine family.

When oxygen in alcohol is replaced by sulphur, no breaking up into sulphide of ethyle and sulphide of hydrogen takes place, as when the oxygen is replaced by chlorine or bromine.

Among the best known compounds there are several of which one atom combines, like an atom of oxygen or of sulphur, with two atoms like hydrogen or chlorine. Thus carbonic oxide, sulphurous acid, and olefiant gas are capable of combining in the proportion of one atom of the radical with two atoms of chlorine, forming the compound $COCl^2$ phosgene, $So^2 Cl^2$ chloro-sulphuric acid, and $C^2 H^4 Cl^2$ Dutch liquid: and these molecules have the same vapour volume as steam $O H^2$. But in the free state the radicals have a vapour volume double as great as the equivalent quantity of oxygen, the atoms $C O$, $S O^2$, $C^2 H^4$ being as bulky as O^2, so that whereas the molecule of oxygen and of sulphur consists of two atoms, that of carbonic oxide consists of one atom only, so also the molecule of sulphurous acid and of olefiant gas.

Another family of very marked characteristics is that consisting of N, P, As, Sb, Bi, each member of which combines with three atoms of hydrogen or of ethyle ($C^2 H^5$), forming basic compounds analogous to ammonia. Their analogy in chemical reactions is also well known, as each of them forms an oxide corresponding to nitrous acid, and another corresponding to nitric acid.

The sulphides of arsenic and antimony are notorious for their great resemblance, and that of arsenious and antimonious acid is scarcely less striking. It even extends to isomorphism of their corresponding salts.

The atomic heat of the four last terms of the series is also very nearly the same, whilst that of nitrogen (examined of course as a gas) is considerably less. Then the molecule of phosphorus and of arsenic consists of four atoms, whilst that of nitrogen consists only of two, showing a variety of constitution, which is by no means to be wondered at, when we recollect that these elements are not uniformly triatomic, but sometimes monatomic, pentatomic, &c., so that the molecule of free nitrogen consists of two monatomic atoms, or two triatomic, whilst the molecule of phosphorus and of arsenic is formed on the ammonia type of one triatomic atom and three monatomic atoms.

Another family may, perhaps, be made up of carbon and silicon, both of which form volatile tetrachlorides, and are sometimes biatomic, sometimes tetratomic in their acids.

Among metals, lithium, sodium, potassium, and probably also the new metals, rubidium, cæsium, and thallium, have many important points of resemblance which show them to be monatomic. They replace hydrogen atom for atom, and form with many bibasic acids both normal and acid salts. Their chlorides form with tetra-chloride of platinum analogous double salts, and their sulphates form, with sulphate of alumina, &c., those well-characterized salts called alums. They do not form basic salts (unless when triatomic, like thallium). They have nearly the same atomic heat.

Silver is remarkable for several of the properties which we have noticed in the alkali metals. It is eminently monatomic, and disinclined to form basic salts. Its atomic heat also shows it to be monatomic. It appears to form an alum, and its sulphate has a great resemblance of form with the anhydrous sulphate of soda.

Gold also must from its specific heat, and the constitution of its two chlorides be classed among the metals which are monatomic or triatomic. Boron is evidently triatomic in its best known compounds, as proved by the ter-chloride and ethylide.

Among metals with strongly basylous properties, Ca, Sr, Ba, Pb, are connected by very close analogies. The general resemblance of their sulphates and carbonates, and the isomorphism of most of them, are too well known to need mention.

But lead has been obtained in combination with Ethyle, and the compound $Pb\ (C^2 H^5)^4$ which corresponds to binoxide of lead, in which the two atoms of oxygen are replaced by four atoms of ethyle, and the compound $Pb\ (C^2 H^5)^3 Cl$ proves beyond a doubt that the metal is there tetrabasic.

Again: lead is pre-eminent for its tendency to form basic salts even with purely monatomic chlorous elements and radicals. Thus ordinary nitrate of lead, when warmed in aqueous solution with ceruse, expels carbonic acid from that compound, and forms the well-known and crystallizable basic nitrate—$Pb \left\{ \begin{matrix} N\ O^3 \\ H\ O. \end{matrix} \right.$ If this be represented upon the water type, it is formed from two molecules of water, $\begin{matrix} H \\ H \end{matrix} O \; \begin{matrix} H \\ H \end{matrix} O$ two atoms of hydrogen, one from each molecule being replaced by the biatomic atom lead, whilst one of the remaining atoms of hydrogen is replaced by $N\ O^2$, thus

$$\begin{matrix} NO^2 \\ Pb^O \\ H^O \end{matrix}$$

But if the binary theory be adopted, it must be represented as lead combined with the radical $N\ O^2$, and also with the radical $H\ O$, and the biatomic lead holds thus two atoms together, just as much as biatomic oxygen holds together ethyle and hydrogen in alcohol. If we mix our lead compound with sulphate of silver, and heat with water, we replace the one atom of lead in it by two atoms of silver, getting a mixture of nitrate of silver and brown hydrated oxide of silver just as the replacement of oxygen in alcohol by Cl^2 forms chloride of ethyle + hydrochloric acid.

We are thus led to consider these metals as biatomic, and to represent their oxides by the old formulæ $Ca\ O$, $Ba\ O$, $Pb\ O$, whilst carbonates, sulphides, and sulphates have formulæ like $Ca\ C\ O^3$, $Ca\ S\ O^3$, $Ca\ S\ O^4$, their chlorides, nitrates, and phosphates have formulæ like $Ca\ Cl^2$, $Ca\ (N\ O^3)^2$, $Ca^3\ (P\ O^4)^2$. Nitrate of potash has thus a similar formula $(N\ O^3\ K)$ to arragonite $C\ O^3\ Ca$, and their isomorphism is no longer surprising. The same remark applies to calc spar and nitrate of soda.

Another analogous group of metals is the triad, magnesium, zinc, and cadmium, all volatile and forming salts which greatly resemble one another, and in many cases isomorphous. The constitution and properties of Frankland's zinc ethyle leaves no doubt of the biatomic character of zinc, for the compound $Zn(C^2 H^5)^2$ has the same molecular volume as ether $O(C^2 H^5)^2$, and if the atom of zinc were taken out and replaced by one atom of oxygen, there would be no change of volume. Then half the ethyle in zinc ethyle is replaceable by iodine, just as half the ethyle in ether is replaceable by potassium.

The biatomic character of this family being thus established, we can extend the conclusion to the other metals which form magnesian oxides, so called from the striking analogy of constitution of several of their salts with the corresponding salt of magnesia. In this manner we are led to adopt for iron, manganese, nickel, cobalt, and copper atomic weights corresponding to biatomic characters. The subsulphide of copper is thus represented by the formula $Cu^2 S$, which is sufficiently similar to that of sulphide of silver, $Ag^2 S$, to remove our surprise at their isomorphism. There is, moreover, in the reactions of alumina, sesqui-oxide of iron, sesqui-oxide of chromium, and sesqui-oxide of manganese, much resemblance. All these are weak bases, and their sulphates form with sulphate of potash those most characteristic salts called alums. The three first are isomorphous in the uncombined state, so that the conclusion established for iron and manganese may be extended to aluminium and chromium. But it is also arrived at by other means, for chromium in combination with oxygen and chlorine forms the well-characterized compound $Cr O^2 Cl^2$ chloro-chromic acid, which contains the same quantity of oxygen and of chlorine as chloro-sulphuric acid in two volumes of vapour, having 52·5 of chromium in the place of the 32 of sulphur of that compound. Again, chromic and sulphuric acids exhibit a marked resemblance of properties, the former being, if anything, even more distinctly bibasic than the latter, and their normal potash salts are isomorphous, so that chromium is abundantly proved to be similar to sulphur in atomicity, and brings in evidence of its own in favour of the biatomic character of aluminium, iron, and manganese. In like manner manganese in manganic acid is connected with sulphur in sulphuric acid, and requires a corresponding biatomic weight. The isomorphism and general analogy of per-manganate of potash with per-chlorate of potash has often been alluded to as pointing to the necessity of representing the former by a formula containing one large atom of manganese, $Mn O^4 K$: but although this formula, by assimilating the expressions for these two similar bodies, removes one difficulty, it creates at the same time another difficulty, by presenting a formula containing only one atom from the first family of elements. The speaker said he would not at present hazard any opinion regarding the propriety of removing this difficulty by doubling the above formulæ, together with that of per-chlorate of potash, although he might remark that the constitution of the basic per-iodate of soda points to the formula $I^2 O^9 Na^4 3 (H^2 O)$.

An exceedingly strong ground for admitting for many heavy metals the atomic weight corresponding to a biatomic character was brought forward some time ago by Wurtz, who pointed out that ıg for oxygen the atomic weight 16, we get a half-molecule of $\frac{H^2O}{2}$ in one molecule of various salts if we consider the heavy monatomic.

her metals are susceptible of reduction by similar analogies to ıss of elements which are biatomic or tetratomic, &c. Thus 'y is proved by the ethylide and methylide to be biatomic by the at the compound for one atom of mercury with two atoms of or of methyle, occupies the same volume in the state of vapour compound of one atom of oxygen with two of ethyle or of .e $Hg(CH^3)^2 = 2$ vols., and we can take out one atom of methyle ıe bi-methylide of mercury, and replace it by an atom of chlorine, ıe, or iodine without disturbing the type, $\genfrac{}{}{0pt}{}{CH^3}{I}Hg$. The com- i-chloride of mercury has, moreover, a vapour volume corre- ng to the biatomic character of the metal, and the same thing good of the vapour of metallic mercury itself, which has the 'olume as the metal cadmium, and probably zinc, and the well- ı biatomic radicals CO, SO^2, C^2H^4, but double the volume of lements oxygen and sulphur. In the present state of our edge the speaker was not aware of any sufficient grounds for ıg which of these two constitutions of the free molecule of a ıic element or radical is to be considered as normal and which ormal. On the one hand, mercury, cadmium, and all known ıic radicals have a molecule containing one atom, while the ıle of oxygen contains two atoms, and that of sulphur two at temperatures and six at lower temperatures. Selenium is at temperatures like sulphur. It has been amply shown by Dr. ; and others that tin is biatomic and tetratomic in its two les, and its compounds with the organic radicals and chlorine, ave no room for doubt on the point.

' similar chains of evidence the remaining metals can be shown ıng to the great biatomic class containing already so many.

ıe vapour densities of the so-called sesqui-chlorides of iron, ıium, and chromium, as determined by Deville, show that the ıle of each of these bodies contains two atoms of metal and six of chlorine, in fact the same quantity of metal as the molecule sesqui-oxide: this fact has been held to be an anomaly from the of view adopted regarding their atomic weights. The speaker ed, however, that so far from being anomalous, these vapour ies are the least which can be reconciled with the conclusion that tals permanently combine with even numbers of atoms from the ımily, for if one atom of iron could on occasion combine with ıtoms of chlorine to form one molecule, the law respecting it assume the not very wise form,—that iron combines with an ıumber of atoms from the first family, except when it combines n uneven number!

ıe fact is, that the sesqui-chlorides are not exceptions to the law, as at first sight they are suspected of being. Precisely the same remarks apply to the so-called subchloride of sulphur of which the molecule is $S^2 Cl^2$, as required by the law. So also cyanogen $C^2 N^2$, acetylene $C^2 H^2$, ethyle $C^4 H^{10}$, &c. &c. Amongst exceptions, the speaker mentioned nitric oxide and calomel, both of which have vapour densities corresponding to the molecular formulæ $N O$ and $Hg Cl$.

Many compounds are known to undergo decomposition on evaporation, and to be reproduced on condensation; thus $N H^5 O$ yields the two molecules $N H^3$ and $H^2 O$, each with its own volume, as also $S O^3 H^2$ yields $S O^2$ and $H^2 O$. $S O^4 H^2$ and $P Cl^5$ are also known to yield on evaporation vapour corresponding to a breaking-up into two molecules; and there are strong reasons from analogy, as well as experimental evidence, to believe such decomposition. As, however, a high authority seems inclined to doubt the decomposition, the matter may be considered as still *sub judice*.

The existence of basic salts of mercury or copper, when apparently monatomic, is another class of apparent exceptions to the law. For if, in the sub-nitrate of mercury, the atom of metal really replaced one atom of hydrogen, just as potassium does in nitrate of potash, there ought not to be basic sub-nitrate of mercury, any more than a basic potash salt; whereas if the sub-nitrate of mercury contains, as the speaker asserted, in one molecule two atoms of metal and two atoms of the salt radical of the nitrates ($N O^3$), then a basic salt is as natural and intelligible a compound as the basic nitrate of the red oxide.

The action of ammonia on calomel confirms the molecular weight $Hg^2 Cl^2$; for the compound $N H^2 Hg^2 Cl$, formed simultaneously with sal ammonia, proves that twice ($Hg Cl$) takes place in the reaction.

[A. W. W.]

ANNUAL MEETING,

Monday, May 2. 1864.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Annual Report of the Committee of Visitors for the year 1863 was read and adopted.

The amount of Contributions from Members and Subscribers in 1863, amounted to £3,423; the Receipts for Subscriptions to Lectures were £716. 12*s*. 6*d*.; the total Income for the year amounted to £5,532. 10*s*. 7*d*.

On Dec. 31, 1863, the Funded Property was £30,107. 14*s.* 11*d.*; and the Balance at the Bankers', £1,056. 14*s.* 9*d.*, with Six Exchequer Bills of £100 each.

Fifty-five New Members were elected in 1853.

A List of Books Presented, amounting in number to 121 volumes, accompanies the Report, making, with those purchased by the Managers and Patrons, a total of 561 volumes (including Periodicals) added to the Library in the Year.

Sixty-three Lectures and Nineteen Evening Discourses were delivered during the year 1863.

Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and to Professor Faraday, and the other Professors, for their services to the Institution during the past year.

The following Gentlemen were unanimously elected as Officers for the ensuing year:—

President—The Duke of Northumberland, K.G. F.R.S.
Treasurer—William Pole, Esq. M.A. F.R.S.
Secretary—Henry Bence Jones, M.A. M.D. F.R.S.

Managers.

George Busk, Esq. F.R.C.S. F.R.S.
Warren De la Rue, Esq. Ph.D. F.R.S.
Sir George Everest, C.B. F.R.S.
John Peter Gassiot, Esq. F.R.S.
John Hall Gladstone, Esq. Ph.D. F.R.S.
William Robert Grove, Esq. M.A. Q.C. F.R.S.
Sir Henry Holland, Bart. M.D. D.C.L. F.R.S.
John Lubbock, Esq. F.R.S.
John Carrick Moore, Esq. M.A. F.R.S.
William Frederick Pollock, Esq. M.A.
Robert P. Roupell, Esq. M.A. Q.C.
Major-Gen. Edward Sabine, R.A. D.C.L. Pres. R.S.
The Right Hon. Lord Stanley, M.P. F.R.S.
Joseph William Thrupp, Esq.
Colonel Philip James Yorke, F.R.S.

Visitors.

John Derby Allcroft, Esq.
The Hon and Rev. Samuel Best.
John Charles Burgoyne, Esq.
George Frederick Chambers, Esq.
John George Dodson, Esq. M.P.
Christopher Darby Griffith, Esq. M.P.
Henry Harwood Harwood, Esq.
Thomas Henry, Esq.
Thomas Hyde Hills, Esq.
Harry Mackenzie, Esq.
John North, Esq.
The Lord Overstone, M.A. F.G.S.
Edmund Packe, Esq.
The Earl Stanhope, D.C.L. F.R.S. Pres. Soc. Antiq.
George Tomline, Esq. M.P.

WEEKLY EVENING MEETING,

Friday, May 6, 1864.

Colonel Philip James Yorke, F.R.S. in the Chair.

Professor Roscoe, F.R.S.

On the Metal Indium and Recent Discoveries on Spectrum Analysis.

Since the spring of 1862, when the speaker delivered a course of three lectures in this Institution on the Spectrum Discoveries, much has been done to increase our knowledge of Spectrum Analysis, but the whole subject is still in its infancy, and the further we advance the more we find remains to be known.

No less than four new elementary bodies have already been discovered by means of Spectrum Analysis: Cæsium and Rubidium, by Bunsen; Thallium, by Mr. Crookes; and Indium, by Reich and Richter, of Freiberg; whilst the foundations of Solar Chemistry, laid by Kirchhoff, have been rendered more secure by the observations of Cooke, in America; Donati, in Italy; and Miller and Huggins, in England.

Cæsium and rubidium were at first only found in one or two mineral waters; they have since been shown to be widely distributed in the vegetable as well as in the mineral kingdom; they have been obtained in considerable quantities from the beet-root salt, and found in the ashes of tea and coffee, thus proving that they occur commonly in soil; whilst, quite recently, M. Pisani has found that a mineral, called pollux, occurring in Elba, contains 34 per cent. of cæsium, this metal having been mistaken for potash in the analyses which had previously been made of this substance. Thallium and its compounds have been obtained in large quantities, and their properties fully investigated by Crookes and Lamy, whilst this metal has not only been found in iron pyrites, but also in large quantities by Schrötter, in the mica of Zinnwald, and in lepidolite, from Moravia. Thallium has been shown by Boettger to occur together with cæsium and rubidium in the mineral water of Nauheim, near Frankfort; Boettger has, moreover, shown that thallium is contained in the vegetable kingdom, he has found it in the yeast of the vinous fermentation; so that thallium exists in wine: also in treacle, tobacco, and chicory. If 4 lbs. of any of these substances are employed, a sufficient quantity of thallium can be obtained as the double platinum-chloride to enable its presence to be easily detected. Professor Bunsen has informed the speaker that he has found a mother liquor from the Hartz, which contains so much thallium, that the

can be obtained by direct precipitation in quantity at the rate
r. per lb. The speaker exhibited the spectrum of the Nauheim
which contains the three new elements; the spectrum of each
is well seen by placing the mixed platino-chlorides in the
ic arc.

rs. Reich and Richter, of Freiberg, in Saxony, have lately dis-
ed a fourth new metal in the Freiberg zinc blende.[*] This metal
een termed Indium, from the two splendid indigo-blue lines which
cterize its spectrum. Through the kindness of Professor Richter,
peaker had been placed in possession of a few grains of this
metal, the spectrum of which was exhibited by the electric

In its chemical relations it resembles zinc, with which it is asso-
in nature; the metal can be reduced before the blowpipe to a
able bead, when it forms a soft, ductile bead, which imparts streaks
per on rubbing, and possesses a colour lighter than that of lead,
about the same as that of tin. The metallic bead dissolves in hydro-
ic acid with the evolution of hydrogen. The oxide of indium is
d as a yellow fusible incrustation when the metal is heated before
owpipe on charcoal. Indium differs from zinc in the insolubility
hydrated oxide in excess of both ammonia and caustic potash.
new element may be separated from all the known metals by pre-
ting its sulphide in alkaline solution, and by throwing down the
ted oxide first with ammonia and then with caustic potash; and,
by precipitating the iron with dilute solution of bicarbonate of
m. The hydrated oxide of indium then remains in solution in
ure state. Indium may be readily detected when present in its
compounds by the deep purple tint which these impart to flame.
haracteristic lines are, however, best seen when a small bead of
m salt is placed between two poles, from which an electric spark
s; the lines In α and In β fall respectively upon divisions 107·5,
40 of the photographic scale of the spectroscope, when Na = 50,
ir $\delta = 100{\cdot}5$. Up to the present time indium has been only found
very smallest quantity, and hence the atomic weight of the metal
the composition of its salts have not yet been determined; in
the speaker was led to infer that Professor Richter sent him
y all the compound of the metal remaining from the investigation
properties, for the purpose of illustrating this discourse. It has
s yet been detected in the zinc blende of Freiberg; but it will,
less, soon be discovered in larger quantities, and its compounds
closely studied.

s regards the spectra of the well-known metals, our knowledge has
much increased by the publication of the second series of Kirchhoff's
of the solar spectrum and the spectra of the chemical elements
millan and Co.). In these Kirchhoff has marked the position of
right lines of no less than thirty metals, and indicated those which,
y coincide with a dark solar line, reveal the presence of the par-

---

[*] Phil. Mag. for March, 1864. Series 4, vol. xxvii. p. 199.

ticular metal in the sun's atmosphere. Kirchhoff's maps now embrace the whole of the visible spectrum from the line A in the extreme red, to the line G in the indigo; beyond these limits the intensity of the light passing through his three prisms became too slight to enable him to draw the lines. The observations thus made of coincidences of metallic with solar lines in the red and indigo portions of the spectrum, confirm the conclusions drawn by Kirchhoff from his earlier observations, with the exception of the presence of potassium. This metal is not seen in the solar atmosphere, the potassium red line is not coincident with the solar line A, as it was supposed to be, nor with any other dark solar line. No metal, in addition to those previously observed, was found to possess lines coincident with solar lines, and hence the number of bodies known to be present in the sun has not been increased.

The experiments of Mr. Huggins on the spectra of the metallic elements, made with an instrument of six prisms, although not yet published in full, promise to add greatly to our knowledge on this subject: one interesting observation may be cited; *viz.* that the spectrum of sodium has been found to contain three pairs of lines in addition to those corresponding to the dark double line D, and that these also coincide with dark solar lines, adding to the evidence previously possessed of the existence of sodium in the sun. The audience had been already made acquainted with Dr. Miller's important researches on the photographic spectra of the metals, and with the valuable observations made by himself and Mr. Huggins on the spectra of the fixed stars. Connected with this part of the subject may be mentioned Professor Stokes's interesting investigation on the long spectrum of the electric spark, in which he shows that the vapour of certain metals, such as iron and magnesium, when heated by the passage of an electric spark, emit rays of so high a degree of refrangibility, that they are situated at a distance from the lines H, ten times as great as that of the whole visible spectrum from A to H. These highly refrangible rays only become visible at the highest temperatures, and they are not seen in the solar spectrum, although the less refrangible iron and magnesium lines are present. Hence it has been suggested that the temperature of the sun must be lower than that of the electric spark in which these lines are developed. This conclusion appears legitimate only if we know that these rays of high refrangibility are not absorbed in passing through our atmosphere; and an investigation of great interest here presents itself for those who ascend into the higher regions of the atmosphere.

The observations of Dr. Robinson upon metallic spectra have led this astronomer to doubt the validity of some of the conclusions arrived at by Kirchhoff concerning the existence of a separate and non-coincident set of lines in the spectrum of each metal. It seems, however, that Dr. Robinson employed only one prism and a low magnifying power, so that we must conclude that the observations from which he deduces the coincidence of certain lines as proving their identity in several etals, cannot impugn the results obtained by help of a larger instru- ent of sufficient power to resolve these apparent coincidences.

The original statement made by Bunsen and Kirchhoff concerning he spectra of the metals still remains unopposed by a single well-stablished fact—the statement, namely, that when a metal is heated p to a certain point, the spectrum of its incandescent vapour contains number of fine bright lines which do not change their position ith increase of temperature, and are not coincident with the lines of ny other known substance. There is, however, no doubt of the fact hat in the spectra of certain metals or metallic compounds new lines re developed by increase of temperature; and also that certain etals, as calcium, barium, and strontium, yield spectra of two kinds; ne of these, seen at the lower temperature, and consisting of broad ands, being resolved at a higher temperature into bright lines. These bright lines do not undergo any further change on elevation of emperature, and characterize the true metallic spectrum, whilst the and-spectrum is probably produced by the incandescent vapour of a etallic compound which is decomposed at a higher temperature.

Our knowledge of the spectra of the non-metallic elements is, as et, in a very incomplete state. To the researches of Plücker, we are pecially indebted for information on this subject; he has shown that ach metalloid possesses a peculiar and characteristic spectrum; ydrogen, for instance, yielding only three bright lines, all of which are oincident with dark solar lines; and nitrogen exhibiting a complicated ries of bands. Plücker has lately come to the conclusion that many on-metallic elementary bodies, and among them sulphur and nitrogen, xhibit two distinctly different spectra when the temperature is altered, this respect resembling the metals of the alkaline earths. This ifference Plücker ascribes to the existence of these elements in two llotropic conditions.

A singular relation with regard to what have been termed the arbon lines was observed by the speaker. It has been stated that ll the various forms of carbon compounds when in the state of incan- escent gas, yield identical spectra. This proves not to be the case; he spectrum obtained from the flame of olefiant gas is different from hat obtained by the electric discharge through a vacuum of the same as; whilst the spark passing through a cyanogen vacuum produces a pectrum identical with that of the olefiant gas-flame, and through the arbonic oxide vacuum a spectrum coincident with that of the spark hrough olefiant gas vacuum.

As an illustration of the application of abstract scientific prin- iples to useful practical purposes, the speaker stated that he had tely applied spectrum analysis to the manufacture of steel by the essemer process. One of the great drawbacks to the successful ractical working of Mr. Bessemer's beautiful process for converting ast-iron directly into steel, has been the difficulty of determining the xact point at which the blast of air passing through the molten metal to be stopped. The conversion of five tons of cast-iron into cast-steel usually occupies from fifteen to twenty minutes, according to the varying conditions of weather, quality of the iron, strength of the blast, &c. If the blast be continued for ten seconds after the proper point has been attained, or if it be discontinued ten seconds before that point is reached, the charge becomes either so viscid that it cannot be poured from the converting vessel into the moulds, or it contains so much carbon as to crumble under the hammer. Up to the present time, the manufacturer has judged of the condition of the metal by the general appearance of the flame which issues from the mouth of the converting vessel. Long experience enables the workman thus to detect, with more or less exactitude, the point at which the blast must be cut off. It appeared to the speaker that an examination of the spectrum of this flame might render it possible to determine this point with scientific accuracy, and that thus an insight might be gained into the somewhat complicated chemical changes which occur in this conversion of cast-iron into steel. At the request of Messrs. John Brown and Co., of the Atlas Works, Sheffield, the speaker investigated the subject, and succeeded in obtaining very satisfactory and interesting results. The instrument employed was an ordinary Steinheil's spectroscope, furnished with photographic scale and lamp, and provided with a convenient arrangement for directing the tube carrying the slit towards any wished-for part of the flame, and for clamping the whole instrument in the required position. By help of such an arrangement the spectrum of the flame can be most readily observed, and the changes which periodically occur can be most accurately noted.

The light which is given off by the flame in this process is most intense; indeed, a more magnificent example of combustion in oxygen cannot be imagined—and a cursory examination of the flame spectrum in its various phases reveals complicated masses of dark absorption bands and bright lines, showing that a variety of substances are present in the flame in the state of incandescent gas. By a simultaneous comparison of these lines in the flame-spectrum with the well-known spectra of certain elementary bodies, the speaker has succeeded in detecting the presence of the following substances in the Bessemer flame:—Sodium, potassium, lithium, iron, carbon, phosphorus, hydrogen, and nitrogen.

A further investigation with an instrument of higher dispersive and magnifying powers than that employed, will doubtless add to the above list; and an accurate and prolonged study of this spectrum will probably yield very important information respecting the nature of the reactions occurring within the vessel. Already the investigation is so far advanced that the point in the condition of the metal at which it has been found necessary to stop the blast can be ascertained with precision; and thus, by the application of the principles of Spectrum Analysis, that which previously depended on the quickness of vision of a skilled eye has become a matter of exact scientific observation.

Another interesting practical application of our knowledge concerning the properties of the kind of light which certain bodies emit when heated, is the employment of the light evolved by burning Magnesium wire for photographic purposes. The spectrum of this light is exceedingly rich in violet and ultra-violet rays, due partly to the incandescent vapour of magnesium, and partly to the intensely-heated magnesia formed by the combustion. Professor Bunsen and the speaker in 1859 determined the chemically active power possessed by this light, and compared it with that of the sun; and they suggested the application of this light for the purpose of photography. They showed* that a burning surface of magnesium wire, which, seen from a point at the sea's level, has an apparent magnitude equal to that of the sun, effects on that point the same chemical action as the sun would do if shining from a cloudless sky at a height of 9° 53′ above the horizon. On comparing the *visible* brightness of these two sources of light, it was found that the brightness of the sun's disc, as measured by the eye, is 524·7 times as great as that of burning magnesium wire when the sun's zenith distance is 67° 22′; whilst at the same zenith distance the sun's *chemical* brightness is only 36·6 times as great. Hence the value of this light as a source of the chemically active rays for photographic purposes becomes at once apparent.

Professor Bunsen and the speaker state in the memoir above referred to, that, "the steady and equable light evolved by magnesium wire, burning in the air, and the immense chemical action thus produced; render this source of light valuable as a simple means of obtaining a given amount of chemical illumination, and that the combustion of this metal constitutes so definite and simple a source of light for the purpose of photo-chemical measurement, that the wide distribution of magnesium becomes desirable. The application of this metal as a source of light may even become of technical importance. A burning magnesium wire of the thickness of 0·297 millimetre, evolves, according to the measurement we have made, as much light as 74 stearine candles of which five go to the pound. If this light lasted one minute, 0·987 metre of wire, weighing 0·120 grammes, would be burnt. In order to produce a light equal to 74 candles burning for ten hours, whereby about 20 lbs. of stearine is consumed, 72·2 grammes (2½ ounces) of magnesium would be required. The magnesium wire can be easily prepared by forcing out the metal from a heated steel press having a fine opening at bottom; this wire might be rolled up in coils on a spindle, which could be made to revolve by clockwork, and thus the end of the wire, guided by passing through a groove or between rollers, could be continually pushed forward into a gas or spirit lamp flame in which it would burn."

It afforded the speaker great pleasure to state that the foregoing suggestion had now been actually carried out. Mr. Edward Sonstadt has succeeded in preparing magnesium on the large scale, and great credit is due to this gentleman for the able manner in which he has brought the difficult subject of the metallurgy of magnesium to its present very satisfactory position.

---

* Phil. Trans. 1859, p. 920.

Some fine specimens of crude and distilled magnesium weighing 8 lbs. were exhibited as manufactured by Mr. Sonstadt's process, by Messrs. Mellor & Co. of Manchester.

The wire is now to be had at the comparatively low rate of 3*d.* per foot; * and half-an-inch of the wire evolves on burning light enough to transfer a positive image to a dry collodion plate; whilst by the combustion of 10 grains a perfect photographic portrait may be taken, so that the speaker believed that for photographic purposes alone the magnesium light will prove most important. The photochemical power of the light was illustrated by taking a portrait during the discourse. In doing this the speaker was aided by Mr. Brothers, photographer, of Manchester, who was the first to use the light for portraiture.

[H. E. R.]

GENERAL MONTHLY MEETING,

Monday, May 9, 1864.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Hon. Henry Frederick Cowper,
George Clive, Esq. M.P.
Lieut.-Col. George Palmer Evelyn,
William Dell, Esq.
William Graham, Esq.

were *elected* Members of the Royal Institution.

The following Professors were re-elected:—

William Thomas Brande, Esq. D.C.L. F.R.S. Hon. Professor of Chemistry;
John Tyndall, Esq. Professor of Natural Philosophy;
Edward Frankland, Esq. Ph. D. F.R.S. Professor of Chemistry.

The Secretary announced the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

William C. Henry, M.D.	£25	0	0
Arthur Giles Puller, Esq.	21	0	0
Bernard E. Brodhurst, Esq.	5	5	0
William Salmon, Esq.	10	0	0

---

* From Messrs. Johnson and Matthey of Hatton Garden.

to the convenient occupation of the Institution a part [illegible] [illegible]
o the Institution, but to a family of the name of Baldry, and
Baldry part came to be sold by auction early in this month. [illegible]
ınd the great depreciation that would arise to the Institution
22 Albemarle Street if this Baldry part should be pur-
by anyone else; and that this Baldry part being now to be
under one lease with the adjoining house, [illegible]. [illegible] [illegible]
was to be sold with that house in one lot, and that if purchased
Institution, the Managers had arranged with a responsible
o take a lease until Michaelmas, 1[illegible], of the whole of the
property, at a rent which would return to the Institution [illegible]
ent. per annum on the purchase-money; and that under these
tances the Managers had sanctioned the purchase of all the
property at the auction for 7,900*l.* The Report concluded by
recommending to the General Meeting of Members to pass a
ion in conformity with the Notice which had been sent to the
rs, pursuant to Chap. XI., Art. 1. of the Bye-Laws, for authoriz-
he sale of sufficient of the consols in the name of the Institution
pleting the purchase.

Meeting thereupon passed a Resolution approving of the Manager[illegible]
ed Report, and authorizing the Sale of Stock in conformity with
Notice which had been sent to the Members, as recommended in
port.

PRESENTS received since the last Meeting were laid on the table
thanks of the Members returned for the same, viz.

-*General of India*—Memoirs of the Geological Survey of India.
tologia Indica. II. 6. III. 1. [illegible]

, *Institute of*—[illegible]

Faraday, Professor, D.C.L., F.R.S.—Memorie della Reale Accademia delle Scienze di Torino. Seconda Serie. Tomo XX. 4to. 1863.

Geological Survey of Canada:—1843-63. 8vo. 1863

Industrial Resources of the Tyne, Wear, and Tees. 8vo. 1864.

Geneve, Société de Physique de—Mémoires. Tome XVII. Partie 1. 4to. 1863.

Geographical Society, Royal—Proceedings, Vol. VIII. No. 3. 8vo. 1864.

Geological Institute, Vienna—Jahrbuch. No. 2. 8vo. 1863–4.

Gilliss, Captain, J. M., U.S.N. (the Superintendent)—Astronomical and Meteorological Observations at the Observatory at Washington in 1862. 4to. 1863.

Horticultural Society, Royal—Proceedings, 1864. No. 6. 8vo.

Linnean Society—Journal of Proceedings, No. 28. 8vo. 1864.

Liverpool Athenæum—Classified Catalogue of the Library. 8vo. 1864.

Mechanical Engineers' Institution, Birmingham—Proceedings, August. 8vo. 1863.

Newton, Messrs.—London Journal (New Series) for April, 1862. 8vo.

Newton, A. V. Esq. (the Author)—On the Patent Laws. (L 14) 8vo. 1864.

Petermann, A. Esq. (the Editor)—Mittheilungen auf der Gesammtgebiete der Geographie. 1864. No. 2. 4to.

Photographic Society—Journal, No. 144. 8vo. 1864.

Royal Society of London—Proceedings, No. 62. 8vo. 1864.

R. C. Carrington: Observations of the Spots of the Sun, 1853-61. 4to. 1863.

Roma, Accademia Pontificia de' Nuovi Lincei—Atti: Anno VII. (1854.) Sess. 3, 4, 5. Anno XIV. (1861.) Sess. 3-7. Anno XV. (1862.) Sess. 1-8. Anno XVI. (1863.) Sess. 1-5. 4to.

Silliman, Professor S. (the Editor)—American Journal of Science. Second Series. No. 110. 8vo. 1864.

Sandys, Sampson, Esq. (the Author)—On National Defence, &c. (K 90) 8vo. 1864.

Taylor, Rev. William, F.R.S. M R I.—W. Strange: The Seven Sources of Health. 16to. 1864.

Toronto University Abstracts of Magnetical Observations at Toronto, 1853-62. 8vo. 1863.

Volpicelli, Professor P. (the Author)—Sulla Elettrostatica Induzione. 4to. 1863.

Yorkshire Philosophical Society—Annual Report for 1863. 8vo.

Hicks, James, Esq.—One of his Improved Mercurial Barometers.

WEEKLY EVENING MEETING,

Friday, May 13, 1864.

Major-Gen. Edw. Sabine, R.A. President R.S. Vice-President R.I.
in the Chair.

John Scott Russell, C.E. F.R.S.

On the Mechanical Nature and Uses of Gun-cotton.[*]

Gun-Cotton is a new power coming under the same category as steam and gunpowder. It is highly dangerous to those who do not possess the necessary knowledge and skill; but, like them, it enormously extends human power, and like them, the skill to use it can be rightly and certainly acquired.

---

[*] For the Chemical History of Gun-Cotton, see Mr. Abel's discourse, p. 265 of this volume.

I. Is gun-cotton stronger than gunpowder? The answer to this is, Yes, sixfold stronger.

By this we mean that if we take a given weight of gun-cotton, say four ounces, if we bore a hole 1½ inch in diameter and 3 feet deep, into hard rock or slate, in a quarry, and put 4 ounces of gun-cotton into it, it will occupy about 1 foot of its length. and the aperture being closed in the usual manner, and a match-line led from the charge to the proper distance from which to fire it; and if we next take 24 ounces of best gunpowder, bore a similar hole, and charge it similarly with gunpowder, and close it in the same way; it has been found that, on these being exploded, the 4 ounces of gun-cotton have produced greater effect, in separating the rock into pieces, than the 24 ounces of gunpowder. The answer is, therefore, that in disruptive explosion the strength of gun-cotton is sixfold that of good gunpowder.

But the disruptive or bursting power of gunpowder is not always the quality for which we value it most, nor the service we require of it. In mining rocks, in exploding shells, in blowing up fortresses, this property is what we value, and this work is what we require. But we do not want to burst our fowling-pieces, our rifles, our cannon. On the contrary, we want to use a force that shall project the projectile out of the gun without bursting the gun, without straining the gun beyond a given moderate limit, which it shall be able to endure. We want therefore a service from gun-cotton which shall be the contrary of destructive to, or disruptive of, the chamber in which it does the work of giving motion to the projectile.

This moderated and modified work, gun-cotton can also perform; and it is the modern discovery of General Lenk, which has enabled us to moderate and modify gun-cotton, to this gentler service. He discovered how to organize, arrange, and dispose mechanically of gun-cotton in such a way that it should be three times stronger than gunpowder. Accordingly, one of his charges of gun-cotton, weighing 16 ounces, projected a 12-pound solid round shot with a speed of 1,426 feet a second, while a charge of gunpowder of 49 ounces gave the same shot a speed of 1,400 feet a second. One-third of the weight of gun-cotton exceeded, therefore, the threefold weight of gunpowder in useful effect.

II. Is gun-cotton more convenient than gunpowder? This is a larger and more various question than the former, and divides itself into various subdivisions.

It is well known to sportsmen, to soldiers, to artillery-men, that gunpowder fouls a gun. A foul residue of soot, sulphur, and potash soils the inside of the gun after every charge. The gun must, somehow, be cleaned after a discharge; if not it fires worse, recoils more, and ceases to do its best. If the gun be a breech-loading gun its mechanism is dirtied, and works less easily. Gun-cotton deposits no residue, leaves the gun clean and clear, and the utmost it does is to leave a gentle dew of clear water on the inside of the bore, this water being the condensed steam which forms one of the products of its decomposition. Gun-cotton is, therefore, superior to gunpowder in not fouling the gun, a result favourable both to quicker and more accurate firing.

It is further a matter of no slight convenience that gun-cotton makes no smoke. In mines the smoke of gunpowder makes the air unbreathable, and for some time after explosion the miners cannot return to their work. In boring the great tunnel of Mont Cenis through the Alps, the delay from smoke of powder alone will postpone the opening of the line for many months. After a properly-conducted explosion of gun-cotton, the workmen may proceed in their work at once without inconvenience.

In casemates of fortresses, gunpowder fills the casemates with foul smoke, and the men speedily sink under the exertion of quick firing. By using gun-cotton it was ascertained that the men could continue their work unharmed for double the quantity of firing. This is partly attributed to the greater heat, and partly to the foulness of the air produced by gunpowder.

But it is under the decks of our men-of-war, that greatest benefit is likely to arise from gun-cotton. Not only does the smoke of a broadside fill the between decks with hot and foul air, but the smoke of the windward gun blinds the sight, and hinders the aim of the leeward. When there is no smoke, as with gun-cotton, the aim of every gun may be precise and deliberate. The diminished heat between decks will also tell powerfully in favour of gun-cotton. In our armour-plated ships also there is more value in breech-loading guns, than in any other use of artillery. It is one of the necessities of breech-loading mechanism, that it be kept clean, and nothing tends more to derange its perfect action than the greater heat which gunpowder imparts to the gun from which it is fired.

That gun-cotton has the convenience of not heating the gun has been thus proved. 100 rounds were fired in 34 minutes with gun-cotton, and the temperature of the gun was raised 90°. 100 rounds were fired with gunpowder, and triple the time allowed to cool the gun, which nevertheless was heated so much as to evaporate water with a hissing sound, which indicated that its temperature was much above 212°. Under these circumstances the firing with gunpowder had to be stopped, while that with gun-cotton was comfortably continued to 180 rounds.

It is also a matter of practical convenience that gun-cotton, inasmuch as it is lighter, can be carried more easily and farther than gunpowder; and it may be wetted without danger, so that when dried again in the open air, it is as good for use as before.

III. We have now to ask—is it cheaper? The answer to this question must be qualified—pound for pound it is dearer; we must herefore judge of its cheapness by its effect, not by weight merely. But where it does six times as much work, it can then be used at six imes the price per pound and still be as cheap as gunpowder. As far s we yet know, the prices of gun-cotton and gunpowder are nearly qual, and it is only therefore where the one has advantages and con-eniences beyond the other, and is more especially suited for some pecific purpose, that it will have the preference. Effective cheap-ess will therefore depend mainly on which of the two does best the articular kind of duty required of it.

To illustrate how curiously these two powers, gun-cotton and gun-owder, differ in their nature, and how the action of gun-cotton may e changed by mechanical arrangements, we may take one kind of work hat is required of both :—If a general want to blow open the gates of city, he orders an enterprising party to steal up to the gate, with a ag containing 100 lbs. of gunpowder, which he nails to the gate, and y a proper match-line he fires the gunpowder and bursts open the ate. If he nailed a bag of gun-cotton of equal weight in the same lace and fired it, the gun-cotton would fail, and the gate would be ninjured, although the 100 lbs. of gun-cotton is sixfold more owerful than the gunpowder. Here, then, gunpowder has the dvantage—both weight and effect considered.

But the fault here lies not in the gun-cotton, but the way of using t. If instead of 100 lbs. of gun-cotton in a bag, 25 lbs. had been aken in a proper box made for this purpose, and simply laid down ear the gate, and not even nailed to it, this 25 lbs. would shiver the ate into splinters. The bag which suits the powder happens not to uit the gun-cotton.

Gun-cotton is therefore a power of a totally different nature from unpowder, and requires complete study to know its nature and nderstand its use. It appears that both gunpowder and gun-cotton ave special qualities, and may be peculiarly suited for peculiar uses. t is the duty of a wise people to make use of both to the ends they ach suit best, without prejudice arising from the accident of novelty r antiquity.

The nature of gun-cotton requires a double study, chemical and echanical. It is not like steam, the same substance, whether in the orm of ice or water or steam. It is one substance when as gun-otton it enters the gun, and quite a different one when it has exploded nd leaves the gun. Not only are the solids which enter converted nto gas, but they form totally new combinations and substances. So hat the marvellous changes which the chemist effects by the magic f his art take place in an instant of time, and during that almost nconceivably minute period of time, in a laboratory intensely heated, ld substances are dissolved, their material atoms are redistributed, ach atom released selects by natural affinity a new partner, these ew unions are cemented, and at the end of this prolific instant totally ew combinations of matter, forming what we call new substances, issue rom the gun. It so happens that of these new substances, formed out of gun-cotton, all are pure transparent gases, while in the case of gunpowder there remain 68 per cent. of solid residue, and only 32 per cent. are pure gases.

MECHANICAL APPLICATIONS OF GUN-COTTON.

The mechanical application of gun-cotton may be considered to be due exclusively to Major-General Lenk, of the Austrian service. Pure gun-cotton becomes either a powerful explosive agent, or a docile performer of mechanical duty, not according to any change in its composition, or variation in its elements or their proportions, but according to the mechanical structure which is given to it, or the mechanical arrangements of which it is made a part. It was General Lenk who discovered that structure was quality, and mechanical arrangement the measure of power, in gun-cotton; and in his hands, a given quantity of the same cotton becomes a mild, harmless, ineffectual firework, a terrible, irresistible, explosive agent, or a pliable, powerful, obedient workman.

The first form which General Lenk bestowed on gun-cotton was that of a continuous yarn or spun thread. Gunpowder is carefully made into round grains of a specific size. Gun-cotton is simply a long thread of cotton fibre, systematically spun into a yarn of given weight per yard, of given tension, of given specific weight. A hank of a given length is reeled, just like a hank of cotton yarn to be made into cloth, and in this state gun-cotton yarn is bought and sold like any other article of commerce.

This cotton yarn converted into gun-cotton may be called, therefore, the raw material of commerce. In this form it is not at all explosive in the common sense of the word. You may set fire to a hank of it, and it will burn rapidly with a large flame; but if you yourself keep out of reach of the flame, and keep other combustibles beyond reach, no harm will happen, and no explosion or concussion will result. If you lay a long thread of it round your garden walk at night, disposing it in a waving line with large balls of gun-cotton thread at intervals, and light one end of the thread, it will form a beautiful firework, the slow lambent flame creeping along with a will-o'-th'-wisp-looking light, only with a measured speed of 6 inches per second, or 30 feet a minute; the wind hastening it or retarding it as it blows with or against the line of the thread. This is the best way to commence an acquaintance with this interesting agent.

Care must be taken not to become too familiar with gun-cotton even in this harmless and playful guise; cotton dresses will readily catch fire from it, and it should not be treated with less care to keep fire from it than gunpowder. In one respect it is less liable to cause danger than gunpowder. Grains of powder are easily dropped through a crevice, and may be sprinkled about in a scarcely noticeable form, but a hank of gun-cotton is a unit, which hangs together and cannot strew itself about by accident.

second form of gun-cotton is an arrangement compounded out elementary yarn. It resembles the plaited cover of a riding-it is plaited round a core or centre which is hollow. In this is match-line, and, although formed merely of the yarn plaited round hollow cord, this mechanical arrangement has at once ed on it the quality of speed. Instead of travelling as before inches a second, it now travels 6 feet a second.

third step in mechanical arrangement is to enclose this cord se outer skin or coating, made generally of India-rubber cloth, this shape it forms a kind of match-line, that will carry fire at a f from 20 to 30 feet per second.

not easy to gather from these changes what is the cause which pletely changes the nature of the raw cotton by mechanical ment alone. Why a straight cotton thread should burn with creeping motion when laid out straight, and with a rapid one ound round in a cord, and again much faster when closed in e air, is far from obvious at first sight; but the facts being so, mature consideration.

cartridge of a common rifle in gun-cotton is nothing more piece of match-line in the second form enclosed in a stout paper-prevent it being rammed down like powder. The ramming which is essential to the effective action of gunpowder, is fatal of gun-cotton. To get useful work out of a gun-cotton rifle, t must on no account be rammed down, but simply transferred place. Air left in a gunpowder barrel is often supposed to be gun; in a gun-cotton barrel, it only mitigates the effect of rge. The object of enclosing the gun-cotton charge in a hard pasteboard cartridge, is to keep the cotton from compression e it room to do its work.

a *fourth* discovery of General Lenk, that to enable gun-cotton orm its work in artillery practice, the one thing to be done is to it room." Don't press it together—don't cram it into small give it at least as much room as gunpowder in the gun, even there be only one-third or one-fourth of the quantity (measured ght). 1 lb. of gun-cotton will carry a shot as far as 3 or 4 lbs. powder; but that pound should have at least a space of 160 ches in which to work.

s law rules the practical application of gun-cotton to artillery. ridge must not be compact, it must be spread out or expanded ull room it requires. For this purpose, a hollow space is pre-in the centre of the cartridge by some means or other. The eans is to use a hollow thin wooden tube to form a core; this ould be as long as to leave a sufficient space behind the shot gun-cotton. On this long core the simple cotton yarn is wound like thread on a bobbin, and sufficiently thick to fill the cham-the gun; indeed, a lady's bobbin of cotton thread is the innocent the most destructive power of modern times—only the wood bobbin must be small in quantity in proportion to the gun-cotton in the charge. There is no other precaution requisite except to enclose the whole in the usual flannel bag.

The artillerist who uses gun-cotton has therefore a tolerably simple task to perform if he merely wants gun-cotton to do the duty of gunpowder. He has only to occupy the same space as the gunpowder with one-fourth of the weight of gun-cotton made up in the bobbin as described, and he will fire the same shot at the same speed. This is speaking in a general way, for it may require in some guns as much as $\frac{1}{3}$ of the weight of gunpowder and $1\frac{1}{3}$ the bulk of charge to do the same work ; a little experience will settle the exact point, and greater experience may enable the gun-cotton to exceed the performance of the gunpowder in every way.

The *fifth principle* in the use of gun-cotton is that involved in its application to bursting uses. The miner wants the stratum of coal torn from its bed, or the fragment of ore riven from its lair ; the civil engineer wishes to remove a mountain of stone out of the way of a locomotive engine ; and the military engineer to drive his way into the fortress of an enemy, or to destroy the obstacles purposely laid in his way. This is a new phase of duty for gun-cotton—it is the work of direct destruction. In artillery you do not want to destroy directly, but indirectly. You don't want to burst your gun, nor even to injure it ; and, we have seen, in order to secure this, you have only to give it room.

The fifth principle, therefore, is, to make it destructive—to cause it to shatter everything to pieces which it touches, and for this purpose you have only to deprive it of room. Give it room, and it is obedient; imprison it, and it rebels. Shut up without room, there is nothing tough enough or strong enough to stand against it.

To carry this into effect, the densest kind of gun-cotton must be used. It must no longer consist of fine threads or hollow texture wound on roomy cores. All you have to do is to make it dense, solid, hard. Twist it, squeeze it, ram it, compress it ; and insert this hard, dense cotton rope or cylinder or cake in a hole in a rock, or the drift of a tunnel, or the bore of a mine ; close it up, and it will shatter it to pieces. In a recent experiment, 6 ounces of this material set to work in a tunnel not only brought down masses which powder had failed to work, but shook the ground under the feet of the engineers in a way never done by the heaviest charges of powder.

To make gun-cotton formidable and destructive, squeeze it and close it up ; to make it gentle, slow, and manageable, ease it and give it room. To make gunpowder slow and gentle, you do just the contrary : you cake, condense, and harden it to make it slow, safe for guns, and effective.

To carry out this principle successfully, you have to carry it even to the extreme. Ask gun-cotton to separate a rock already half-separated, it will refuse to comply with your request. Give it a light burden of earth and open rock to lift, it will fail. If you want it to do the work, you must invent a *ruse*,—you must make believe at the work is hard, and it will be done. Invert a difficulty and at it between the cotton and its too easy work, and it will do it. The evice is amazingly successful. If the cotton have work to do that light and easy, you provide it with a strong box, which is hard to urst, a box of iron for example: close a small charge, that would be armless, in a little iron box, and then place that box in the hole here formerly the charge exploded harmless, and in the effort it akes to burst that box, the whole of the light work will disappear efore it.

The first trial of English-made gun-cotton was made at Stowmarket n the spring of 1864. A charge of 25 lbs. not only destroyed a tree-tockade, but shattered it into matchwood.

It is, therefore, the nature of gun-cotton to rise to the occasion and o exert force exactly in proportion to the obstacle it encounters. For estructive shells this quality is of the highest value. You can make our shell so strong that nothing can resist its entrance, and when rrived at its destination no shell can prevent its gun-cotton charge rom shivering it to fragments.

These are the main principles in the mechanical manipulation of un-cotton which will probably render it for the future so formidable n instrument of war. Resistances too great for gunpowder only uffice to elicit the powers of gun-cotton. On the other hand, in its lementary state as the open cotton yarn, it is playful, slow, gentle, nd obedient; there is scarcely any mechanical drudgery you can equire of it that it is not as ready and fit to do as steam, or gas, or ater, or other elementary power.

In conclusion, I may be asked to say as a mechanic what I think an be the nature and source of this amazing power of gun-cotton. In eply let me ask, Who shall say what takes place in that pregnant instant of time when a spark of fire enters the charge, and one-hundredth art of a second of time suffices to set millions of material atoms loose rom fast ties of former affinity, and leaves them free every one to elect his mate, and uniting in a new bond of affinity, to come out of hat chamber a series of new-born substances? Who shall tell me all hat happens then? I will not dare to describe the phenomena of that regnant instant. But I will say this, that it is an instant of intense eat—one of its new-born children is a large volume of steam and ater. When that intense heat and that red-hot steam were united in he chamber of that gun and that mine, two powers were met whose nion no matter yet contrived has been strong enough to compress and onfine. When I say that a gun-cotton gun is a steam-gun, and when I say that at that instant of intense heat, the atoms of water and the toms of fire are in contact atom to atom, it is hard to believe that it hould not give rise to an explosion infinitely stronger than any case f the generation of steam by filtering the heat leisurely through the etal skins of any high-pressure boiler.

[J. S. R.]

The EARL OF ROSSE, F.R.S. M.R.I., in the Chair.

JAMES NASMYTH, ESQ. M.R.I.

On the Physical Aspects of the Moon's Surface.

As the Moon's hemisphere, which is ever turned towards us, h
features illuminated in opposite directions during her monthly pa
in her orbit around the earth, every part of it is exposed in tu
the rays of the sun, which fall on the details of its features in const
varying inclinations; and it is from this circumstance that we
such favourable opportunities afforded to us of obtaining a very e
knowledge of the configuration of the details in question, as well
their height or depression above or below the mean level of the M
general surface. Thus it is that we are enabled most careful
scrutinize her remarkable surface; and should we have drawn
hasty inferences from one set of observations, the opportunity is u
presented to us in the course of a fortnight, or at farthest a mon
correct them if erroneous, or to verify them if accurate, and to p
further investigations that may be suggested by reflection on wh
had last observed.

In these respects telescopic visits to the surface of the Moon
more correct and reliable results than would many a visit to per
of our world where the scenery to be surveyed is not, perhaps,
veniently accessible: and even when it is reached, the traveller
be surrounded by circumstances which very seriously interfere
his personal comfort, or disturb that tranquillity which is so requ
a condition for close and accurate observation, and thus lead hi
hasty conclusions, which he has no future opportunity to rectify.
strong contrast with such circumstances is the

long course of assiduous observation and reflection, an amount of intimate acquaintance with the physical structure of the Moon's exterior, in many important respects far more accurate than is our knowledge of that portion of the earth.

In order rightly to interpret the details of the Moon's surface, as revealed to us by the aid of the telescope, we ought, in the first place, to bear in mind the true nature of volcanic action, namely, that while it has reference to the existence of intense temperature and molten matter, it does not derive its origin from *combustion*, considered as such in a strictly chemical sense, but proceeds from an incandescent condition, induced in matter by the action of that great cosmical law which caused an intense heat to result from the gravitation of particles of matter towards a common centre. These particles, originally existing in a diffused condition, were, by the action of gravitation, made to coalesce, and so to form a planet. Volcanic action, then, has in all probability for its source the heat consequent upon the collapse of such diffused matter, resulting in that molten condition through which there is strong reason to believe all planetary bodies to have passed in their primitive state, and of which condition the geological history of our earth furnishes abundant evidence. Thus the molten lava which we see issuing from an active volcano on the earth, is really and truly a residual portion of that molten matter of which the entire globe once consisted.

In reference to the nature and origin of that eruptive force which had again and again, in the early periods of the Moon's history, caused the remaining molten matter of her interior to be ejected from beneath her solidified crust, and so to assume nearly every variety of volcanic formation in its most characteristic aspect, the key to these may be found in the action of that law which pervades almost all matter in a molten condition, namely, that "molten matter occupies less bulk, weight for weight, than the same material when it has ceased from the molten state;" or, in other words, "that matter in a molten state is specifically more dense than the same material in a solidified condition." Thus it is that in passing from the molten to the solid state the normal law is resumed, and expansion of bulk either just immediately precedes or accompanies solidification. It is, therefore, in this expansion in the bulk of the solidifying matter, beneath the Moon's crust, that we are to look for the true cause of that eruptive or ejective action which has resulted in the displacement, *surfaceward*, of the fluid portion of the Moon's internal substance; a displacement which has manifested itself in nearly every variety of volcanic formation, such as circular craters with their central cones or mountains of exudation, cracked districts, &c.; all these variations of well-recognized volcanic phenomena being intermingled and overlaid one upon the other in the most striking and wonderful manner.

It may, however, be very reasonably and naturally asked, "What evidence have I that the features I refer to have any relation to volcanic action at all?" In reply to such a question I would direct the inquirer's attention to one single feature which, I conceive, demonstrates more completely than any other the fact of volcanic action having (at however remote a period) existed in full activity in the Moon. The special feature to which I would refer is the central cone that may be observed within those "Ring-formed mountains," as they have been termed. "The central cone" is a well-known and distinctive feature in terrestrial volcanoes. It is the residue of the last expiring efforts of a once energetic eruptive volcanic action, which had thrown the ejected matter to such a considerable distance round about the volcanic vent, that in its descent it had accumulated around in the form of a ring-shaped mountain or crater; whilst on the subsidence of this volcanic energy, the ejected matter was deposited in the immediate vicinity of the vent or volcanic orifice, and thus arose the "central cone."

Anyone who is familiar with terrestrial volcanic craters must, at the first glance at those which are scattered in such infinite numbers over the Moon's surface, detect this well-known analogous feature, the central cone, and at once reasonably infer that these similar forms arose from a common cause, that cause being no other than volcanic action, accompanied by all its most marked characteristics.

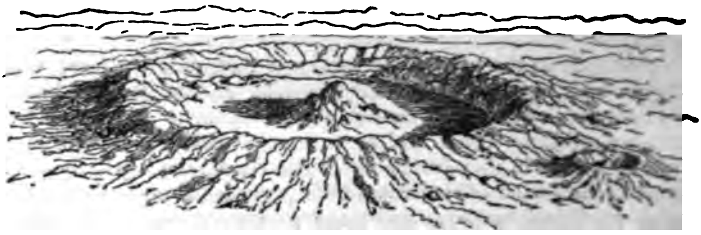


FIG. 1.[*]

Fig. 1 represents a fair average type of the structure of a Lunar Volcanic Crater with its central cone A.

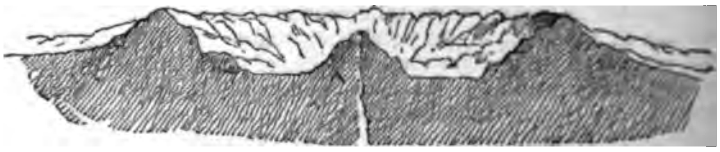


FIG. 2.

Fig. 2. The same in section.

---

[*] The woodcuts have been kindly lent by Mr. Churchill, publisher of the 'Quarterly Journal of Science.' They illustrated Mr. J. Nasmyth's article in the July number of that work.

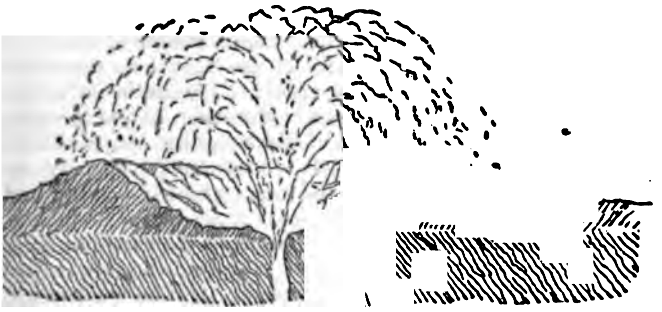


Fig. 3.

. 3 is the section of a Lunar Crater, showing how by the ı, and subsequent deposition of the ejected matter, the circular all or crater had been formed.

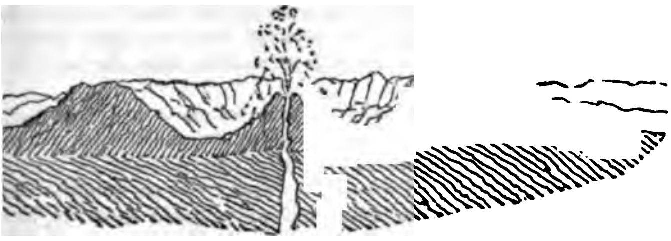


Fig. 4.

4. The section of the same, exhibiting the manner in which the one had resulted from the expiring efforts of the eruptive action.

xamining the Moon's surface, we cannot but be impressed with dimensions of many of the volcanic craters with which her is studded. Craters of thirty miles and upwards in diameter o means uncommon, and the first impression on the mind in e to such magnitudes is one of astonishment, that so small a s the Moon (whose magnitude is only about $\frac{1}{49}$th that of the hould exhibit evidence of volcanic violence so far greater than t we have on the earth. This apparent paradox will, however, r when we come to consider that in consequence of the Moon o much less than the earth, the force of gravity on its ex- not above $\frac{1}{6}$th of that on the earth, and that the weight of r materials on its surface is reduced in the latter proportion, n the other hand, by reason of the small magnitude of the d its proportionately much larger surface in ratio to its magni- e rate at which it parted with its original cosmical heat must n vastly more rapid than in the case of the earth. Now, as the e and eruptive action and energy are in proportion to the greater rate of cooling, those forces must have been much greater in the first instance; and, operating as they did on matter so much reduced in weight as it must be on the surface of the Moon, we thus find in combination two conditions most favourable to the display of volcanic force in the highest degree of violence. Moreover, as the ejected material in its passage from the centre of discharge had not to encounter any atmospheric resistance, it was left to continue the primary impulse of the ejection in the most free and uninterrupted manner, and thus to deposit itself at distances from the volcanic vent so much greater than those of which we have any example in the earth, as to result in the formation of the craters of vast magnitude so frequently encountered in a survey of the Moon's surface. In like manner we find the ejected matter piled up to heights such as create the utmost astonishment. Lunar Mountains of 10,000 feet high are of frequent occurrence, while there are several of much greater altitude, some reaching the vast height of 25,000 feet, and that almost at one bound, as they start up directly from the plane over which they are seen to cast their long black, steeple-like shadows for many a mile; whilst at other times they intercept the rays of the sun upon their highest peaks many hours before their bases emerge from the profound darkness of the long lunar night.

Among the many terribly sublime scenes with which the Moon's surface must abound, none can be grander than that which would present itself to the spectator, were he placed inside of one of these vast volcanic craters (Tycho, for instance), surrounded on every side by the most terrific evidences of volcanic force in its wildest features.

In such a position he would have before him, starting up from the vast plane below, a mighty obelisk-shaped mountain of some 9,000 feet in height, casting its intense black shadow over the plateau; and partly up its slope he would see an amphitheatrical range of mountains beyond, which, in spite of their being about forty miles distant, would appear almost in his immediate proximity (owing to the absence of that "aerial perspective," which in terrestrial scenery imparts a softened aspect to the distant object), so near, indeed, as to reveal every cleft and chasm to the naked eye! This strange commingling of near and distant objects, the inevitable visual consequence of the absence of atmosphere or water, must impart to lunar scenery a terrible aspect; a stern wildness, which may aptly be termed unearthly. And when we seek to picture to ourselves, in addition to the lineaments and conditions of the lunar landscape, the awful effect of an absolutely black firmament, in which every star, visible above the horizon, would shine with a steady brilliancy (all causes of scintillation or twinkling being absent, as these effects are due to the presence of variously heated strata, or currents in our atmosphere), or of the vivid and glaring sunlight, with which we have nothing to compare in our subdued solar illumination, made more striking by the contrast of an intensely black sky; if, we say, we would picture to ourselves the wild and unearthly scene that would thus be presented to our gaze, we must search for it in the recollection of some fearful dream.

That such a state of things does exist in the Moon we have no reason whatever to doubt, if we may be permitted to judge from inferences reasonably and legitimately deduced from the phenomena on its surface revealed by the telescope; neither can there be a question as to the presence there of the same brilliant tints and hues which accompany volcanic phenomena in terrestrial craters, and which must lend additional effect to the aspect of lunar scenery. Nor must we omit, whilst touching upon the scene that would meet the eye of one placed on the Moon's surface, the wonderful appearance that would be presented by our globe, viewed from the side of the Moon which faces earthward. Possessing sixteen times the superficial area, or four times the diameter, which the Moon exhibits to us, situated high up in the lunar heavens, passing through all the phases of a mighty moon, its external aspect ever changing rapidly as it revolves upon its axis in the brief space of four-and-twenty hours, what a glorious orb it would appear! Whilst its atmospheric phenomena, due to its alternating seasons, and the varying states of the weather, would afford a constant source of interest. But, alas! there can be none to witness all these glories, for if ever man was justified in forming a conclusion which possesses the elements of certainty, it is that there can be no organized form of life, animal or vegetable, of which we have any cognizance, that would be able to exist upon the Moon.

Every condition essential to vitality, with which we are conversant, appears to be wanting. No air, no water, but a glaring sun, which pours its fierce burning rays without any modifying influence for fourteen days unceasingly upon the surface, until the resulting temperature may be estimated to have reached fully 212°; and no sooner has that set on any portion of the lunar periphery than a withering cold supervenes; the "cold of space" itself, which must cause the temperature to sink, in all probability, to 250° below zero. What plant, what animal could possibly survive such alternations of heat and cold recurring every fourteen days, or the accompanying climatic conditions?

But let us not suppose, because the Moon is thus unfitted for animal or vegetable existence as known to us, that it is necessarily a useless waste of extinct volcanoes. Apart from its value as "a lamp to the earth," it has a noble task to perform in preventing the stagnation that would otherwise take place in our ocean, which would, without its influence, be one vast stagnant pool, but is now maintained in constant, healthy activity, through the agency of the tides that sweep our shores every four-and-twenty hours, bearing away with them to sea, all that decaying refuse which would otherwise accumulate at the mouths of rivers, there to corrupt, and spread death and pestilence around. This evil, then, the Moon arrests effectively, and with the tides for a mighty broom, it daily sweeps and purifies our coasts of all that might be dangerous or offensive.

But there is still another duty that she fulfils—namely, i
forming the work of a "tug" in bringing vessels up our tidal
Dwellers in seaports, or those who reside in towns situated
tidal streams, have excellent opportunities of observing and app
ing her value in her towing capacity; and, indeed, it may with
be said that no small portion of the corn with which we are now
and of the coal that glows in our firesides, is brought almost
our very doors by the direct agency of the Moon.

[J.

WEEKLY EVENING MEETING,

Friday, May 27, 1864.

Henry Bence Jones, M.D. F.R.S. Hon. Secretary, and Vi
President, in the Chair.

Reginald Stuart Poole, Esq.
BRITISH MUSEUM.

On Greek Coins as illustrating Greek Art.

1. *Introduction.*—It has been long known that Greek coins
important monuments of Greek art. K. O. Müller constantly
them in his great work on the Archæology of Art (*Archäologie*
Kunst), and had he been able thoroughly to study a large collect
he would have rendered the present attempt needless. Yet, notwi
standing the general agreement and this illustrious example, Gr
coins have not yet been the subject of an essay defining their pla
documents in the history of art.

2. *Definitions.*—Under the term art, sculpture and painting are
intended, with the intermediate province of bas-relief, to which coins
reliefs in miniature, belong. Sculpture represents character; pain
expression. Character is the general and permanent aspect of
face and body as denoting the dominant quality. We can trace in
features and form the effect of study, or of idleness, of pride, or
humility. Expression is the transient but intense effect of some sud
feeling, such as love or hatred, daring or terror. It is illustrative
this distinction that we feel that whereas we look at a sculptured
of the best style, a face in a fine picture seems to look at us. Ba
relief partakes sometimes of the characteristics of sculpture, somet
of those of painting.—(Comp. *Müller, Arch. der Kunst*, § 27.)

3. *Our Knowledge of Greek Art.*—Our present knowledge of Gr

from that derived from coins, is extremely scanty. Of under which bas-relief may here be included, we have e and uncertain information. Literature gives us the names of artists and some idea of their styles. In the works that recognize the characteristics pointed out by literature. But famous names of ancient sculpture, only works of Phidias, pas and his fellow-artists at Halicarnassus, are known to us. architectural sculptures from the Parthenon and the Mauso-pily united at our national museum, acquaint us thoroughly styles of these masters; but when we look for a work of or Lysippus, we look in vain. In the museums of Europe a few statues of such surpassing excellence that they must be he greatest sculptors, but it has been impossible to guess their The majority of famous statues forms but a Græco-Roman f inferior and even corrupted copies, made to suit the oman collectors by artists who could not invent, and wanted y or the skill to copy accurately.

owledge of Greek painting scarcely deserves the name. The n of literature, necessarily more vague than in the case of art, is wholly unsupported by any remains. It would be an reek painting to cite the feeble frescoes of Pompeii. The ner of evidence is derived from bas-reliefs and vase-paintings. er are sometimes pictorial, but as they have lost what at least of background, they had, they only show us design gement, not the essential characteristic of painting, the repre-of light. The latter are monuments of the skill of the drawing, though they fail in exactly the same manner, for f the most rudimentary kind of designs, and from their neces-y execution, could never have attained any higher character.

lue of Coins.—Greek coins are of every age of Greek art, ery city of the Greek world—of every age from the period g infancy before the Persian War, until its destruction under n rule—of every city from Thasos to Cyrene, from Marseilles . Every Greek city was constantly sending forth coins pes varied in accordance with the rich power of invention eek mind. From such a mass of evidence, it must be o obtain some valuable generalizations. For a correct we require not only a large number of instances, but the classing them. Greek sculpture fulfils only the first Greek coins fulfil both. Without induction, the bases of le science have been laid down; and what has been done on's discovery, first in natural science and then in learning, ns to be effected in the archæology of art.

al Character of Greek Art.—The speaker claimed to have l that Greek coins fall into classes representing great lo This might have been expected, as all art shows t stic. This was illustrated by the cases of the modern g, and of Gothic as well as Arab architecture. 'I same law obtained in Greek art, K. O. Müller has incidentally suggested: the coins prove it.

The date of the best examples of art in the coins is from B.C. 450 to B.C. 350, from not long after the repulse of the Persians to the overthrow of the liberties of Greece by Philip, the age of the highest political, literary, scientific, and artistic excellence of the nation.

6. *The Schools.*—The chief and leading school—the term school being used in its geographical sense as distinguished from style, which is the effect produced upon art by a leading artist—was that of Greece itself, including Macedon and Thrace. Its works are eminently sculpture-like (Greece produced the great sculptors); they may be enlarged; the forms are compact; they represent character instead of expression, and are marked by repose and truthfulness. The favourite material is silver.

The west coast of Asia-Minor produced the Ionian school, the pictorial style of which reminds us that the three greatest names in the list of Greek painters, Zeuxis, Parrhasius, and Apelles, were of natives of this country. The works of this school may be enlarged: its forms are free and flowing, dishevelled hair and streaming drapery; it delights in representing expression instead of character, the transient instead of the constant. The favourite materials were the warmer metal gold, and what is but pale gold, electrum.

In Sicily and Italy a school flourished which combined the highest execution with a lower kind of design. Unaided by the influence of sculpture or painting, neither of which owes a single name of celebrity to the western colonies, it lived upon repeating itself, and so fell into a mannered and eclectic style. Its works cannot be enlarged without injury, on account of the exaggeration of form. The style is usually compact, but occasionally indulges in a timid freedom. It represents neither character nor expression, unless we are to admit, for instance, but one character for all female heads. In place of either it puts manner. It displays a certain hardness and cramped drawing that indicate a limitation to one kind of material and to minute work.

Intermediate between the schools of Greece and Ionia is the school of Crete, which, copying nature rather than following sculpture or painting, goes half-way from the gravity of the Greek ideal to the expressiveness of the Ionian. It is picturesque without being pictorial, if a distinction drawn from usage may be allowed. It oscillates between character never strong, and expression never intense. Its want of strength is relieved by its love of nature. It excels in the portrayal of animal and vegetable subjects, and delights in perspective and foreshortening.

Far in the East, where Greek civilization struggled in vain against the destructive influence of Oriental formalism, art could never emancipate itself from a dependence on architecture. The Asiatic school is architectural: the forms are hard and straight; they are never developed.

We may distinguish these schools by assigning to each its most arked characteristic. The school of Greece is sculpture-like; the hool of Ionia picture-like; the school of Sicily and Italy gem-like; e school of Crete picturesque; and the school of Asia architectural.

The distinctive characteristics of the schools were then illustrated y a comparison and separate criticism of some of their best works, presented by enlarged copies. It is unfortunately impossible to peat these observations in the present abstract, as without drawings rresponding to the diagrams, they would not only be difficult to nderstand, but might even convey ideas essentially different from ose intended.

It was observed that the discovery of schools to which were due the ifferences in the coins, would tend to render more definite our knowdge of Greek art in general. Not only did sculpture and painting ourish most where the coins most showed their influence, but in the se of sculpture it was remarked that classification would be aided by knowledge of the various treatments of bas-relief, and that thus it ould be shown that the schools extended throughout the range of the indred arts. Thus a new basis might be laid down for the archæology f art.

The speaker concluded with some general remarks on the national alue of the study of art, on the prospects of art in England, and on e assistance that the critical knowledge of Greek works would give to ose wishing to promote the growth of art in this country.

[R. S. P.]

WEEKLY EVENING MEETING,

Friday, June 3, 1864.

ir Henry Holland, Bart. M.D. F.R.S. Vice-President, in the Chair.

Edward Frankland, Esq. F.R.S.

PROFESSOR OF CHEMISTRY, ROYAL INSTITUTION.

On Recent Chemical Researches in the Royal Institution.

Amongst the branches of inquiry that have engaged the attention of hemists during the past fifteen years, there can scarcely [illegible] pinions as to the paramount importance of those [illegible] ave had for their object the discovery of the [illegible] hemical compounds, and especially of [illegible] y thus studying the architecture of these [illegible] cquainted with the plans according to which [illegible] hem under the influence of what we [illegible] enabled to imitate her operations. The vast number of organic compounds that can now be produced, without the aid of life in any form, some of them even constituting a part of the food of man, affords ample testimony to the importance of this field and the success with which it has been cultivated.

The ultimate analytical composition of a chemical compound affords us little or no information available for the production of that compound, artificially; but the moment the internal arrangement of the atoms becomes known, the constructive process at once suggests itself. Such a problem may be attacked in two distinct ways, either by taking the compound to pieces, or by building it up from its proximate constituents. More than twelve years ago, the speaker had applied the latter or synthetical process to the investigation of organic compounds containing metals, some of the results of which he had communicated to the members on a previous occasion. A like scrutiny must be applied to other families of organic substances if we are to become equally acquainted with their molecular construction. It was the application of the synthetical process to an important family of organic substances, that had formed the basis of the investigations recently carried on in the chemical laboratory of the Institution. In the execution of this work the speaker had been enthusiastically joined by his friend, Mr. Duppa, who had in an eminent degree contributed to whatever success had attended their labours.

The family of organic acids thus attacked, and which is represented by lactic acid, had for some years past excited the interest and attention of chemists, but although much laborious investigation had been expended upon it, especially by Kolbe and Wurtz, yet the constitution of these acids was still far from being established. Like any effort to overcome a difficulty, such an investigation required the selection of a plan of attack, and the preparation of the agents, or weapons, by which the assault was to be made. The speaker had already proved in a paper communicated to the Royal Society, that oxalic acid was the basis or model of the family of acids to be investigated. This fact showed the path by which the subject was to be approached, and he then went on to describe the principles according to which the weapons were constructed.

In Mechanics, the engineer proportions the force which he employs to the effect required to be produced, and it was considered one of the greatest achievements in such control of mechanical force, when Mr. Nasmyth's steam-hammer could be made, at one moment to deliver a blow gentle enough to break the shell of a nut without crushing the kernel, and at the next to descend with a force sufficient to smash a block of granite and shake the ground beneath it. As in mechanics, where we deal with masses, so in chemistry, where we have to do with atoms, it is also necessary to apply a properly graduated amount of force, and to apply it in the right direction. Chemistry was yet far behind mechanics in this faculty of graduating force, but by availing ourselves of certain chemical reactions, we had the power, as it were, of gradually storing up force in the atoms of bodies, and of delivering the blow when the force had become strong enough to effect the change required. In this way the comparatively inert radicles or molecules, methyl, ethyl, amyl, &c., could be invested with chemical energy sufficient to force their entrance into oxalic acid. The process of thus endowing these radicles with force was likened to the gradual winding up of a weight to the height necessary for the production of a given effect by its subsequent fall. For this purpose a force external to the atoms to be elevated was obviously required. The first supply of this force was taken from sodium; but sodium, although competent to raise the molecules of ethyl or methyl to a great elevation, was yet too rough in the use of its power, for if we attempted, by its sole agency, to elevate these molecules, they were actually torn to pieces by the violence of the effort. The action of the sodium must, therefore, be moderated by combining it with mercury; much of its power was thus lost, but sufficient still remained for the purpose, if rightly employed.

This sodium amalgam on being brought into contact with the iodides of methyl, ethyl, or amyl refused to exert any action, but on the addition of a few drops of acetic ether, which acted in this case like a ferment, the sodium separated the iodine from the ethyl, whilst the latter united itself with the mercury.

$$\underbrace{2C_2\,H_5\,I}_{\text{Iodide of Ethyl}} + \underbrace{Hg\left\{\begin{matrix}Na\\ \\ Na\end{matrix}\right.}_{\text{Sodium Amalgam}} = \underbrace{Hg\left\{\begin{matrix}C_2\,H_5\\ \\ C_2\,H_5\end{matrix}\right.}_{\text{Mercuric Ethide}} + \underbrace{2\,Na\,I}_{\text{Iodide of Sodium}}$$

By this association with mercury, the energy of the ethyl was greatly increased, but it still lacked sufficient power for its attack upon oxalic acid; having once commenced its ascent, however, the further elevation of the ethyl became comparatively easy. It was only necessary to digest the mercuric ethide, procured as above described, with metallic zinc, at a temperature of 100° C. for several hours, in order to replace the mercury with zinc, by which means zinc ethyl was obtained.

$$\underbrace{Hg\left\{\begin{matrix}C_2\,H_5\\ \\ C_2\,H_5\end{matrix}\right.}_{\text{Mercuric Ethide}} + Zn. = \underbrace{Zn.\left\{\begin{matrix}C_2\,H_5\\ \\ C_2\,H_5\end{matrix}\right.}_{\text{Zinc Ethyl}} + Hg$$

The zinc ethyl thus obtained possessed far greater energy than the mercuric ethide from which it was derived,* and, in fact, in this compound, the ethyl became fully armed for the contemplated expedition. The speaker, however, showed that its power could be still further increased by the addition of the metal lithium. By these processes th following chemical compounds and weapons of attack had been manufactured :—

---

* The intense chemical energy of zinc ethyl was shown experimentally by a fountain of the liquid, which played perpendicularly to the height of 6 or 8 feet, forming a fiery jet of blue and white flame.

NAME.	FORMULA.	
Mercuric Methide	$\mathrm{Hg}\left\{\begin{array}{l}CH_3\\CH_3\end{array}\right.$	
Mercuric Iodo-methide . . .	$\mathrm{Hg}\left\{\begin{array}{l}CH_3\\I\end{array}\right.$	
Mercuric Ethide	$\mathrm{Hg}\left\{\begin{array}{l}C_2H_5\\C_2H_5\end{array}\right.$	
Mercuric Iodo-ethide . . .	$\mathrm{Hg}\left\{\begin{array}{l}C_2H_5\\I\end{array}\right.$	
Mercuric Chlor-ethide . . .	$\mathrm{Hg}\left\{\begin{array}{l}C_2H_5\\Cl\end{array}\right.$	
Mercuric Amylide.	$\mathrm{Hg}\left\{\begin{array}{l}C_5H_{11}\\C_5H_{11}\end{array}\right.$	
Mercuric Iod-amylide. . . .	$\mathrm{Hg}\left\{\begin{array}{l}C_5H_{11}\\I\end{array}\right.$	
Mercuric Chlor-amylide . . .	$\mathrm{Hg}\left\{\begin{array}{l}C_5H_{11}\\Cl\end{array}\right.$	
Zincmethide.	$\mathrm{Zn}\left\{\begin{array}{l}CH_3\\CH_3\end{array}\right.$	
Zincethide	$\mathrm{Zn}\left\{\begin{array}{l}C_2H_5\\C_2H_5\end{array}\right.$	
Zincamylide.	$\mathrm{Zn}\left\{\begin{array}{l}C_5H_{11}\\C_5H_{11}\end{array}\right.$	
Lithio-mercuric Methide . .	$\begin{array}{l}\mathrm{Hg}''\\\mathrm{Li}'\end{array}\left\{\begin{array}{l}CH_3'\\CH_3'\\CH_3'\end{array}\right.$	?
Lithio-mercuric Ethide . . .	$\begin{array}{l}\mathrm{Hg}''\\\mathrm{Li}'\end{array}\left\{\begin{array}{l}C_2H_5'\\C_2H_5'\\C_2H_5'\end{array}\right.$	?
Lithio-zinc Methide	$\begin{array}{l}\mathrm{Zn}''\\\mathrm{Li}'\end{array}\left\{\begin{array}{l}CH_3'\\CH_3'\\CH_3'\end{array}\right.$	?
Lithio-zinc Ethide.	$\begin{array}{l}\mathrm{Zn}''\\\mathrm{Li}'\end{array}\left\{\begin{array}{l}C_2H_5'\\C_2H_5'\\C_2H_5'\end{array}\right.$	?

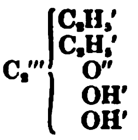
The speaker then described the action of several of these bodies upon oxalic acid, or rather oxalic ether. This action consisted in the removal of one atom of oxygen from oxalic acid, and its substitution by two atoms of ethyl, methyl, &c. Thus, by the action of zincethyl, oxalic acid was transformed into leucic acid—a body that had previously been obtained from animal tissues, especially from the spleen and lungs. By acting upon oxalic ether with the zinc compounds of other organic radicles, a large number of acids belonging to the lactic series, and hitherto unknown, could be produced. Many of these acids were isomeric with each other, that is, possessed the same percentage composition, but differed in their interior architecture. Thus leucic acid was susceptible of no less than nine isomeric modifications, three of which had already been obtained by the method now described. The following table shows the internal structure of these isomeric leucic acids :—

$C_2'''\begin{cases}C_2H_5'\\C_2H_5'\\O''\\OH'\\OH'\end{cases}$	$C_2'''\begin{cases}C_2H_5'\\H'\\O''\\OC_2H_5'\\OH'\end{cases}$	$C_2'''\begin{cases}C_2H_5'\\CH_3'\\O''\\OCH_3'\\OH'\end{cases}$
$C_2'''\begin{cases}CH^{3\prime}\\CH^{3\prime}\\O''\\OC_2H_5'\\OH'\end{cases}$	$C_2'''\begin{cases}C_3H_7'\\CH_3'\\O''\\OH'\\OH'\end{cases}$	$C_2'''\begin{cases}C_3H_7'\\H'\\O''\\OCH_3'\\OH'\end{cases}$
$C_2'''\begin{cases}CH_3'\\H'\\O''\\OC_3H_7'\\OH'\end{cases}$	$C_2'''\begin{cases}C_4H_9'\\H'\\O''\\OH'\\OH'\end{cases}$	$C_2'''\begin{cases}H'\\H'\\O''\\OC_4H_9'\\OH'\end{cases}$

The following is a list of acids which, with their compounds, have thus been produced and investigated during the past year in the laboratory of the Institution.

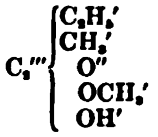
Name.	Formula.
Dimethyloxalic Acid No. 1 .	$C_2'''\begin{cases}CH_3'\\CH_3'\\O''\\OH'\\OH'\end{cases}$
Dimethyloxalic Acid No. 2 .	$C_2'''\begin{cases}CH_3'\\H'\\O''\\OCH_3'\\OH'\end{cases}$

Leucic Acid No. 1 . . . .



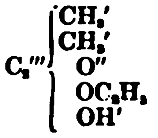
$$C_2'''\left\{\begin{array}{l}C_2H_5'\\ C_2H_5'\\ O''\\ OH'\\ OH'\end{array}\right.$$

Leucic Acid No. 2 . . . .



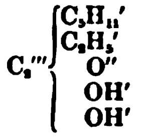
$$C_2'''\left\{\begin{array}{l}C_2H_5'\\ CH_3'\\ O''\\ OCH_3'\\ OH'\end{array}\right.$$

Leucic Acid No. 3 . . . .



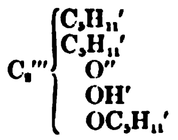
$$C_2'''\left\{\begin{array}{l}CH_3'\\ CH_3'\\ O''\\ OC_2H_5\\ OH'\end{array}\right.$$

Ethyl-amyl Oxalic Acid . .



$$C_2'''\left\{\begin{array}{l}C_5H_{11}'\\ C_2H_5'\\ O''\\ OH'\\ OH'\end{array}\right.$$

Diamyl-oxalic Amyl-ether . .



$$C_2'''\left\{\begin{array}{l}C_5H_{11}'\\ C_5H_{11}'\\ O''\\ OH'\\ OC_5H_{11}'\end{array}\right.$$

These reactions proved that lactic acid, the representative of this family of acids, was also cast in the mould of oxalic acid. Thus, the latter deadly organic body was converted by the removal of one atom of oxygen and its substitution by one of hydrogen and one of methyl into the harmless acid of sour milk, a constituent of the juices of the human body, and an agent, no doubt, of importance in the transformations attending animal life. A similar marvellous transmutation of character is met with in the highly poisonous arsenic acid, which, by the exchange of one atom of oxygen for two of methyl, is converted into the innocuous, though perfectly soluble, cacodylic acid.

The speaker concluded as follows:—Here, then, we have a most prolific reaction, capable of furnishing an immense number of new organic bodies, and at the same time indicating to us the very simple manner in which nature evolves some of her, apparently, most complex results. By a species of progressive development, this simply organized oxalic acid becomes gradually elevated, cultivated, and transformed into bodies, which, when viewed by one ignorant of their true origin, appear to possess a hopeless complexity. Not only do we now gain a clear insight into the architecture of these acids, but we can take the very elements of which they are composed, and build them up unaided by any vital processes. We need not even go for oxalic acid, our very type or model, either to the wood-sorrel, or the lichen, which, by means of this acid, corrodes the rock upon which it grows; for we have the power both to lay the foundation and to build the superstructure of these organic bodies, without the least assistance from either animal or vegetable life. And is it too much to hope, that, by analogous inductive scrutiny, even the most obscure and complex physiological phenomena of life itself will one day yield to scientific research, and become to us as clear and simple as they are now dark and unintelligible? But to accomplish this, the human intellect must prepare itself for efforts far more difficult than any it has yet made. Hitherto the more palpable and simple phenomena of nature have been the first to attract the attention of philosophers, whilst the more recondite and hidden, constituting increasingly difficult subjects of research, have been left for future explorers. Thus, although we are still scarcely advanced beyond the condition of children gathering pebbles on the shore of the boundless ocean of knowledge, yet those pebbles, never easy to find, are now no longer left dry on the beach. They must be dragged from the grip of the waves by patient and cunning toil. Difficulties innumerable and appalling confront us, but let the human intellect be only left free and untrammelled, and it will surely accomplish the task set before it.

[E. F.]

GENERAL MONTHLY MEETING,

Monday, June 6, 1864.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Secretary announced that his Grace the President had nominated the following Vice-Presidents for the ensuing year:—

William Robert Grove, Esq. M.A. Q.C.
Sir Henry Holland, Bart. D.C.L. F.R.S.
Henry Bence Jones, M.D. F.R.S. *Secretary.*
William Pole, Esq. F.R.S. *Treasurer.*
Major-General Sabine, Pres. R.S.
The Lord Stanley, M.P. F.R.S.

William Ackland, Esq. was *elected* a Member of the Royal Institution.

The Secretary announced the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

Sir Henry Holland, Bart. (*6th annual donation*) . .	£40	0	0
Sir Roderick I. Murchison (*2nd annual donation*) . .	20	0	0
Alfred Hooper, Esq.	10	0	0

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Governor-General of India, The (through the Asiatic Society, Bengal)—F. Hall: Contribution towards an Index to the Bibliography of the Indian Philosophical Systems. 8vo.
The Mahabhāshya (edited by Dr. Ballantyne, unfinished). fol.
Secretary of State for India—Bombay Magnetical and Meteorological Observations in 1862. 4to. 1863.

Agricultural Society, Royal—Journal, No. 52. 8vo. 1864.
Architects, Royal Academy of British—Proceedings. 4to. May, 1864.
Astronomical Society, Royal—Monthly Notices, 1863–4, No. 6.
Bavarian Academy, Royal—Sitzungsberichte, 1864. Band I. Heft 1, 2. 8vo.
Annalen der Sternwarte bei München. IV. Supplementenband. 8vo.
Beale, Lionel S. M.B. F.R.S. (the Author)—On Certain Nerve-Centres. 4to. 1864. (Phil. Trans. R. S., 1863.)
British Meteorological Society—Proceedings. Nos. 11, 12. 8vo. 1864.
Chemical Society—Journal for May, 1864. 8vo.
Editors—Artizan for May, 1864. 4to.
Athenæum for May, 1864. 4to.
Chemical News for May, 1864. 4to.
Engineer for May, 1864. fol.
Horological Journal for May, 1864. 8vo.
Journal of Gas-Lighting for May, 1864. 4to.
Mechanics' Magazine for May, 1864. 8vo.
Medical Circular for May, 1864. 8vo.
Practical Mechanics' Journal for May, 1864. 4to.
Technologist for May, 1864. 8vo.
Geological Society—Journal, No. 78. 8vo. 1864.
Mechanical Engineers' Institution, Birmingham—Proceedings, August: II. 8vo. 1863.
Newton, Messrs.—London Journal (New Series) for May, 1862. 8vo.
Petermann, A. Esq. (the Editor)—Mittheilungen auf der Gesammtgebiete der Geographie. 1864. No. 3. 4to.
Photographic Society—Journal, No. 145. 8vo. 1864.
Royal Society of London—Proceedings, Nos. 63, 64. 8vo. 1864.
Silliman, Professor S. (the Editor)—American Journal of Science. Second Series. No. 111. 8vo. 1864.
Twining, Thomas, Esq. M.R.I.—Report of Committee on Dwellings' Improvement in the Metropolis. (K 90 1864.)
Vereins zur Beförderung des Gewerbfleisses in Preusen—Verhandlungen, Jan. and Feb. 1864. 4to.

WEEKLY EVENING MEETING,

Friday, June 10, 1864.

WILLIAM ROBERT GROVE, Esq. M.A. Q.C. F.R.S. Vice-President, in the Chair.

JOHN TYNDALL, Esq. F.R.S. M.R.I.

PROFESSOR OF NATURAL PHILOSOPHY, ROYAL INSTITUTION.

On a Magnetic Experiment.

THERE are two words which are very often employed in scientific ritings—matter and force. The definition of each involves the onception of the other. We know nothing of force save through its perations upon matter, and we know nothing of matter save through he manifestations of its force. The characteristics of any force must e sought in the material changes which it is competent to produce. Some years ago I felt a great interest in the subject of magnetism, and n those years I devised an apparatus to enable me to investigate ertain mechanical effects which accompany the act of magnetization. I wished to apply this apparatus to diamagnetic bodies as well as aramagnetic ones—to bodies such as bismuth, as well as to bodies uch as iron. I intend this evening to show you the action of this nstrument, and to give, if I can, some explanation of the experiments f others which have been confirmed by my own.

Let us pass quickly in review the excitation of this wonderful ower of magnetism. Here is a strong horseshoe magnet set upright, nd here is a bent bar of steel, whose arms are the same distance apart s those of the horseshoe magnet. I draw the bent steel bar over the nds, or the poles, as they are called, of the magnet. It suddenly btains the power of attracting this iron keeper and holding it fast. reverse the stroke of the steel bar: its virtue has now disappeared; t is no longer competent to attract the keeper. I continue the stroke f the steel bar in the last direction, and now it is again competent to ttract the iron: thus I can at will magnetize and demagnetize this ent piece of steel.

Here is a fine permanent magnet constructed by Logeman of Haarlem, and competent to carry a great weight. Here, for example, s a dish of iron nails which it is able to empty. At the other side of he table you observe another mass of metal, bent like the Logeman nagnet, but not, like it, naked. This mass, moreover, is not steel, ut iron, and it is surrounded by coils of copper wire. It is inte o illustrate the excitement of magnetism by electricity. A present moment this huge bent bar is so inert as to be incapable of carrying a single grain of iron. I now send an electric current through the coils that surround it, and its power far transcends that of the steel magnet on the other side. It can carry fifty times the weight. It holds a 56lb. weight attached to each of its poles. and it empties this large tray of iron nails when they are brought sufficiently near it. I interrupt the current: the power vanishes, and the nails fall.

Now the magnetized iron cannot be in all respects the same as the unmagnetized iron. Some change must take place among the molecules of the iron bar at the moment of magnetization. And one curious action which accompanies the act of magnetization I will now try to make sensible to you. Other men laboured, and we are here entering into their labours: the effect I wish to make manifest was discovered by Mr. Joule,* and was subsequently examined by MM. De la Rive, Wertheim, Marian, Matteucci, and Wartmann. It is this. At the moment when the current passes through the coil surrounding the electro-magnet, a clink is heard emanating from the body of the iron, and at the moment the current ceases a clink is also heard. In fact, the acts of magnetization and demagnetization so stir the atoms of the magnetized body that they, in their turn, can stir the air and send sonorous impulses to our auditory nerves.

I have said that the sounds occur at the moment of magnetization, and at the moment when magnetization ceases; hence, if I can devise a means of making and breaking in quick succession the circuit through which the current flows, I can obtain an equally quick succession of sounds. I do this by means of a contact-breaker which belongs to a Ruhmkorff's induction coil. Here is a monochord, and a thin bar of iron stretches from one of its bridges to the other. This bar is placed in a glass tube, which is surrounded by copper wire. I place the contact breaker in a distant room, so that you cannot hear its noise. The current is now active, and every individual in this large assembly hears something between a dry crackle and a musical sound issuing from the bar in consequence of its successive magnetization and demagnetization.

Hitherto we have occupied ourselves with the iron which has been acted upon by the current. Let us now devote a moment's time to the examination of the current itself. Here is a naked copper wire which is quite inert, possessing no power to attract these iron filings. I send a voltaic current through it; it immediately grapples with the filings, and holds them round it in a thick envelope. I interrupt the current, and the filings fall. Here is a compact coil of copper wire which is overspun with cotton to prevent contact between the convolutions. At present the coil is inert; but now I send a current through it: a power of attraction is instantly developed, and you see that it is competent to empty this plate of iron nails.

---

* The sound, I find, was first noticed by Mr. Page.—J. T., 16th June.

Thus we have magnetic action exhibited by a body which does not contain a particle of the so-called magnetic metals. The copper wire is made magnetic by the electric current. Indeed, by means of a copper wire through which a current flows we may obtain all the effects of magnetism. I have here a long coil, so suspended as to be capable of free motion in a horizontal direction: it can move all round in a circle like an ordinary magnetic needle. At its ends I have placed two spirals of platinum wire which the current will raise to brilliant incandescence. They are glowing now, and the suspended coil behaves in all respects like a magnetic needle. Its two ends show opposite polarities: it can be attracted and repelled by a magnet, or by a current flowing through another coil; and it is so sensitive that the action of the earth itself is capable of setting it north and south.

There is an irresistible tendency to unify in the human mind; and, in accordance with our mental constitution, we desire to reduce phenomena which are so much alike to a common cause. Hence the conception of the celebrated Ampère that a magnet is simply an assemblage of electric currents. Round the atoms of a magnet Ampère supposed minute currents to circulate incessantly in parallel planes; round the atoms of common iron he also supposed them to circulate, but in all directions—thus neutralizing each other. The act of magnetization he supposed to consist in the rendering of the molecular currents parallel to a common plane, as they are supposed to be in a permanent magnet.

This is the celebrated theory of molecular currents propounded by Ampère. You observe it consists in the application of conceptions obtained from sensible masses of matter to insensible or atomic masses. Let us follow out this conception to what would appear its legitimate consequences. I have said that we obtain both attractions and repulsions from electric currents: all these effects are deduced from one law, which is, *that electric currents flowing in the same direction attract each other, while, when they flow in opposite directions, they repel each other.* Let me illustrate this law rapidly. Here are two flat coils suspended facing each other, and about eight inches apart. I send a current through both, causing it to flow through them in the same direction; the coils instantly clash and cling together in virtue of their mutual attraction. I now reverse the current through one of them, and they fly a yard asunder, in virtue of their mutual repulsion. And now one of them twists its suspending wire so as to turn its opposite face to the other coil; the currents are now again in the same direction, and the coils clash and cling as in the first instance. Imagine, then, our molecular currents flowing round the atoms of this iron bar in planes perpendicular to the length of the bar. From the law just enunciated we should infer the mutual attraction of those currents; and from this attraction we should be disposed to infer the *shortening* of the bar at the moment of magnetization. Here, for example, is a coil of copper wire suspended vertically; the end of the coil dips into this little basin of mercury. From a small voltaic battery behind I send a current through the coil; and, because it passes in the same of the magnetic curves is now before you. And you observe, when I tap the glass, how the particles attach themselves by their ends, and how the curves close in upon each other. They try to attach themselves thus and close thus up in the solid iron bar: the consequence is that the longitudinal expansion is exactly counterbalanced by the transverse contraction, so that the *volume* of the bar remains unchanged.

But can we not bring a body with movable particles within an electro-magnetic coil? We can; and I will now, in conclusion, show you an experiment devised by Mr. Grove, which bears directly upon this question, but the sight of which, I believe, has hitherto been confined to Mr. Grove himself. At all events, I am not aware of its ever having been made before a large audience. I have here a cylinder with glass ends, and it contains a muddy liquid. This muddiness is produced by the magnetic oxide of iron which is suspended mechanically in water. Round the glass cylinder I have coiled five or six layers of covered copper wire; and here is a battery from which a current can be sent through the coil. First of all, I place the glass cylinder in the path of the beam from our electric lamp, and, by means of a lens, cast a magnified image of the end of the cylinder on the screen. That image at present possesses but feeble illumination. The light is almost extinguished by the suspended particles of magnetic oxide. But, if what I have stated regarding the lines of force through the bar of magnetized iron be correct, the particles of the oxide will suddenly set their longest dimensions parallel to the axis of the cylinder, and also in part set themselves end to end when the current is sent round them. More light will be thus enabled to pass; and now you observe the effect. The moment I establish the circuit the disc upon the screen becomes luminous: I interrupt the current, and gloom supervenes; I re-establish it, and we have a luminous disc once more.

The apparatus, as I have stated, was really invented to examine whether any mechanical effect of this kind could be detected in diamagnetic bodies; but hitherto without result. And this leads me to remark on the large ratio which the failures of an original inquirer bear to his successes. The public see the success—the failure is known to the inquirer alone. The encouragement of his fellow-men, it is true, often cheers the investigator and strengthens his heart; but his main trials occur when there is no one near to cheer him, and when, if he works aright, he must work for duty and not for reputation. And this is the spirit in which work has been executed in this Institution, by a man who has, throughout his life, turned a deaf ear to such allurements as this age places within the reach of scientific renown; and it behoves every friend of this Institution to join in the wish that *that* man's spirit may continue to live within its walls, and that those who come after him may not shrink from his self-denial while endeavouring to merit a portion of his fame.

[J. T.]

GENERAL MONTHLY MEETING,

Monday, July 4, 1864.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

General Sir Edward Lugard, K.C.B. and
John Ruskin, Esq.

were *elected* Members of the Royal Institution.

The Chairman announced the following addition to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

Thomas John Kent, Esq. £5 5 0

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Antiquaries, Society of—Proceedings. Second Series. Vol. I. No. 8. Vol. II. No. 1-4. 8vo. 1861-3.
Asiatic Society of Bengal—Journal, No. 293. 8vo. 1864.
Astronomical Society, Royal—Monthly Notices, 1863-4: No. 7.
Chemical Society—Journal for June, 1864. 8vo.
Editors—Artizan for June, 1864. 4to.
  Athenæum for June, 1864. 4to.
  Chemical News for June, 1864. 4to.
  Engineer for June, 1864. fol.
  Horological Journal for June, 1864. 8vo.
  Journal of Gas-Lighting for June, 1864. 4to.
  Mechanics' Magazine for June, 1864. 8vo.
  Medical Circular for June, 1864. 8vo.
  Practical Mechanics' Journal for June, 1864. 4to.
  Technologist for June, 1864. 8vo.
Franklin Institute of Philadelphia—Journal, No. 460. 8vo. 1864.
Held, Dr. Joseph—Staat und Gesellschaft. 2ter Theil. 8vo. Leipzig. 1863.
Irish Academy, Royal—Transactions. Vol. XXIV. 3 Parts. 4to.
  Proceedings. Vol. VIII Parts 1-6. 8vo. 1861-4.
Linnean Society—Journal and Proceedings, No. 23. 8vo. 1864.
Medico-Chirurgical Society, Royal—Proceedings. Vol. IV. No. 5. 8vo. 1864.
Newton, Messrs.—London Journal (New Series): June, 1862. 8vo.
Petermann, A. Esq. (*the Editor*)—Mittheilungen auf der Gesammtgebiete der Geographie. 1864. No. 4. 4to.
Photographic Society—Journal, No. 146. 8vo. 1864.
Statistical Society of London—Journal. Vol. XXVII. Part 2. 8vo. 1864.

of the magnetic curves is now before you. And you observe, when I tap the glass, how the particles attach themselves by their ends, and how the curves close in upon each other. They try to attach themselves thus and close thus up in the solid iron bar: the consequence is that the longitudinal expansion is exactly counterbalanced by the transverse contraction, so that the *volume* of the bar remains unchanged.

But can we not bring a body with movable particles within an electro-magnetic coil? We can; and I will now, in conclusion, show you an experiment devised by Mr. Grove, which bears directly upon this question, but the sight of which, I believe, has hitherto been confined to Mr. Grove himself. At all events, I am not aware of its ever having been made before a large audience. I have here a cylinder with glass ends, and it contains a muddy liquid. This muddiness is produced by the magnetic oxide of iron which is suspended mechanically in water. Round the glass cylinder I have coiled five or six layers of covered copper wire; and here is a battery from which a current can be sent through the coil. First of all, I place the glass cylinder in the path of the beam from our electric lamp, and, by means of a lens, cast a magnified image of the end of the cylinder on the screen. That image at present possesses but feeble illumination. The light is almost extinguished by the suspended particles of magnetic oxide. But, if what I have stated regarding the lines of force through the bar of magnetized iron be correct, the particles of the oxide will suddenly set their longest dimensions parallel to the axis of the cylinder, and also in part set themselves end to end when the current is sent round them. More light will be thus enabled to pass; and now you observe the effect. The moment I establish the circuit the disc upon the screen becomes luminous: I interrupt the current, and gloom supervenes; I re-establish it, and we have a luminous disc once more.

The apparatus, as I have stated, was really invented to examine whether any mechanical effect of this kind could be detected in diamagnetic bodies; but hitherto without result. And this leads me to remark on the large ratio which the failures of an original inquirer bear to his successes. The public see the success—the failure is known to the inquirer alone. The encouragement of his fellow-men, it is true, often cheers the investigator and strengthens his heart; but his main trials occur when there is no one near to cheer him, and when, if he works aright, he must work for duty and not for reputation. And this is the spirit in which work has been executed in this Institution, by a man who has, throughout his life, turned a deaf ear to such allurements as this age places within the reach of scientific renown; and it behoves every friend of this Institution to join in the wish that *that* man's spirit may continue to live within its walls, and that those who come after him may not shrink from his self-denial while endeavouring to merit a portion of his fame.

[J. T.]

GENERAL MONTHLY MEETING,

Monday, July 4, 1864.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

General Sir Edward Lugard, K.C.B. and
John Ruskin, Esq.

were *elected* Members of the Royal Institution.

The Chairman announced the following addition to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

Thomas John Kent, Esq. £5 5 0

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Antiquaries, Society of—Proceedings. Second Series. Vol. I. No. 8. Vol. II. No. 1-4. 8vo. 1861-3.
Asiatic Society of Bengal—Journal, No. 293. 8vo. 1864.
Astronomical Society, Royal—Monthly Notices, 1863-4: No. 7.
Chemical Society—Journal for June, 1864. 8vo.
Editors—Artizan for June, 1864. 4to.
  Athenæum for June, 1864. 4to.
  Chemical News for June, 1864. 4to.
  Engineer for June, 1864. fol.
  Horological Journal for June, 1864. 8vo.
  Journal of Gas-Lighting for June, 1864. 4to.
  Mechanics' Magazine for June, 1864. 8vo.
  Medical Circular for June, 1864. 8vo.
  Practical Mechanics' Journal for June, 1864. 4to.
  Technologist for June, 1864. 8vo.
Franklin Institute of Philadelphia—Journal, No. 460. 8vo. 1864.
Held, Dr. Joseph—Staat und Gesellschaft. 2ter Theil. 8vo. Leipzig. 1863.
Irish Academy, Royal—Transactions. Vol. XXIV. 3 Parts. 4to.
  Proceedings. Vol. VIII Parts 1-6. 8vo. 1861-4.
Linnean Society—Journal and Proceedings, No. 23. 8vo. 1864.
Medico-Chirurgical Society, Royal—Proceedings. Vol. IV. No. 5. 8vo. 1864.
Newton, Messrs.—London Journal (New Series): June, 1862. 8vo.
Petermann, A. Esq. (the Editor)—Mittheilungen auf der Gesammtgebiete der Geographie. 1864. No. 4. 4to.
Photographic Society—Journal, No. 146. 8vo. 1864.
Statistical Society of London—Journal. Vol. XXVII. Part 2. 8vo. 1864.

Tyndall, Professor, F.R.S.—Proceedings of the Kilkenny Archæological Society. Vol. IV. 8vo. 1862-3.

Herschel, Alex. Esq.—Four Photograph Slides, being the Radiant Points of Four different Showers of Stars occurring in the Year 1863–4.
Model of Shooting Star (of Aug. 10, 1863).
A Photographic Delineation of the Appearance of a Meteor.

Tyndall, Prof.—A Syren.

Royal Institution of Great Britain.

GENERAL MONTHLY MEETING,

Monday, November 7, 1864.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

Dádábhái Naoroji, Esq.

as *elected* a Member of the Royal Institution.

Bernard Augustus Hewitt, Esq.

s *admitted* a Member of the Royal Institution.

A Legacy of £63 had been received, bequeathed by the late **Beriah** **tfield**, Esq. M.P. M.R.I.

The Chairman announced the following additions to "The Donation und for the Promotion of Experimental Researches" (*see* page 151).

Professor Faraday (2nd Annual Donation)	£20 0 0
J. P. Gassiot, Esq. F.R.S. (ditto)	20 0 0
J. P. Gassiot, Esq. jun. (ditto)	20 0 0

The **Presents** received since the last Meeting were laid on the ble, and the thanks of the Members returned for the same: viz.—

From

overnor-General of India—Memoirs of the Geological Survey of India: Palæontologica Indica. III. 2–5. 4to. 1864.

ustees of the British Museum—Catalogue of MS. Additions: 1846–7. 8vo. 1864.

gistrar-General of Ireland—Weekly Return of Births and Deaths in Dublin, 1864. 8vo.

tuaries, Institute of—Assurance Magazine. Nos. 56, 57. 8vo. 1864.

ricultural Society of England, Royal—Journal, No. 53. 8vo. 1864.

nerican Academy of Arts and Sciences—Proceedings, Vol. VI. No. 11–22.

nerican Philosophical Society—Proceedings, Vol. IX. No. 70. 8vo. 1863.

tiquaries, Society of—Proceedings. Second Series. Vol. II. No. 5. 8vo. 1863.

iatic Society of Bengal—Journal, No. 294. 8vo. 1864.

iatic Society, Royal—Journal, New Series. Vol. I. Part 1. 8vo. 1864.

tronomical Society, Royal—Monthly Notices, 1864: Nos. 8, 9. 8vo.

bbage, Charles, Esq. (*the Author*)—Passages from the Life of a Philosopher. 8vo. 1864.

Bache, Professor A. D. (the Superintendent)—The United States Coast Survey Report for 1861. 4to.

Bell and Daldy, Messrs.—Rev. George Williams; Dr. Pierotti and his Assailants; or, A Defence of Jerusalem Explored. (K 91) 8vo. 1864.

T. G. Bonney—The Holy Places at Jerusalem; or, Fergusson's Theory and Pierotti's Discoveries. (K 91) 8vo. 1864.

Boston Society of Natural History—Journal, Vol. VII. No. 4. 8vo. 1863.

Proceedings, Vol. IX. No. 12–20. 8vo. 1863–4.

British Association for the Advancement of Science—Report of the 33rd Meeting held at Newcastle, 1863 8vo. 1864

Chemical Society—Journal for August, September, and October, 1864. 8vo.

Churchill, Messrs.—Quarterly Journal of Science for July and October, 1864. 8vo.

Dean, John, M.D. (the Author)—The Gray Substance of the Medulla Oblongata and Trapezium. (With Photographs.) 4to. 1864.

Dublin Society, Royal—Journal, No 31. 8vo. 1864.

Edinburgh Royal Observatory—Astronomical Observations. Vol. XII. (1855-9 4to. 1863.

Elliot, John Lettsom, Esq. M.R.I.—Rev. John Puckle: Church and Fortress of Dover Castle. 8vo. 1864.

Editors—Artizan for July to October, 1864. 4to.

Athenæum for July to October, 1864. 4to.

Chemical News for July to October, 1864. 4to.

Engineer for July to October, 1864. fol.

Horological Journal for July to October, 1864. 8vo.

Journal of Gas-Lighting for July to October, 1864. 4to.

Mechanics' Magazine, for July to October, 1864. 8vo.

Medical Circular for July to October, 1864. 8vo.

Pharmaceutical Journal for July to October, 1864.

Practical Mechanics' Journal for July to October, 1864. 4to.

Egerton, Sir P. M. De Grey, Bart. M.P. M.R.I.—Report on Weather Fore-Casts. (P 8) fol. 1864.

Report on Ordnance Survey. (P 8) fol. 1864.

Captain Palliser's Exploration of a Portion of British North America. P 8 fol. 1864.

Faraday, Professor, D.C.L. F.R.S.—Kais. Akademie der Wissenschaften: Wien.

Denkschriften: Band XXII. 4to. 1864.

Sitzungsberichte: Math. Nat. Classe. I. Abth. Band XLVII. 4, 5. Band XLVIII. Band XLIX. 1. 8vo. 1863–4. II. Abth. Band XLVII. 5 Band XLVIII. Band XLIX. 1. 8vo. 1863–4.

Almanach: 1863. 16to.

Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger. 8vo. 1862–3.

Franklin Institute of Philadelphia—Journal, Nos. 461-465. 8vo. 1864.

Geographical Society, Royal—Proceedings, Vol. VIII. Nos. 4, 5, 6. 8vo. 1864.

Geological Institute, Vienna—Jahrbuch. 1864. No. 1. 8vo.

Glasgow Philosophical Society—Proceedings, Vol. V. No. 4. 8vo. 1864.

Gray, Dr. J. E., F.R.S. (the Author)—On Museums. (K 91) 8vo. 1864

Hull Literary and Philosophical Society—Annual Report. 8vo. 1864.

Irish Academy, Royal—Transactions. Vol. XXIV. 2 Parts. 4to. 1864.

Linnean Society—Journal and Proceedings, Nos. 29, 30. 8vo. 1864.

Lubbock, John, Esq. M.R.I. (the Author)—Cave Men. (From Nat. Hist. Rev. 1864.

Madrid, Royal Academy of Sciences of—Memorias: Tomo II. III. VI. 4to. 1863-4.

Resumen de las Actas. 1861 à 1862. 8vo. 1863.

Libros del Saber de Astronomia del Rey D. Alfonso X. de Castilla. Ed. M. Rico y Sinobas. 2 vols. fol. 1863.

Mechanical Engineers' Institution, Birmingham—Proceedings, November, 1863 January, 1864. 8vo.

Medico-Chirurgical Society, Royal—Proceedings. Vol. IV. No. 6. 8vo. 1864

Meteorological Society, British—Proceedings, Nos. 13, 14. 8vo. 1864.

Max, Esq. (*the Author*)—Lectures on the Science of Language. Second
ss. 8vo. 1864.
a, Sir R. I. K.C.B. M.R.I. (*the Author*)—Address at Anniversary Meeting
ie Royal Geographical Society, May 23, 1864. 8vo.
Messrs.—London Journal (New Series): July to October, 1864. 8vo.
V. Bertrand, Esq. (*the Author*)—Monograph of the House of Lempriere.
vately Printed.) 4to. 1862.
n, A. Esq. (*the Editor*)—Mittheilungen auf der Gesammtgebiete der
graphie. 1864. Nos 5–9. Ergänzungsheft, 3. 4to.
phic Society—Journal, Nos. 147–150. 8vo. 1864.
M. J. (*the Author*)—Sur un Problème curieux de Magnétisme. (Mém.
l. de Belgique: Tome XXXIV.)
B. (*the Publisher*)—Catalogue of Books in Classes. 8vo. 1864.
riety of Literature—Transactions. Vol. VIII. Part 1. 8vo. 1864.
ciety of London—Proceedings, Nos. 66–67. 8vo. 1864.
phical Transactions for 1863, Part 2; for 1864, Part 1. 4to. 1864.
ciety of Sciences Royal, Leipsic—Abhandlungen. 2 Parts. 4to. 1864.
te. 4 Parts. 8vo. 1864.
Professors (*the Editors*)—American Journal of Science, Nos. 112, 113.
1864.
William, Esq. M.R.I. (*the Author*)—Catalogue of the Works of Cornelius
cher. 8vo. 1864.
ian Institution, Washington—Smithsonian Contributions to Knowledge,
XIII. 4to. 1864.
onian Collections. Vol. V. 8vo. 1864.
onian Report: 1862. 8vo.
l Society of London—Journal. Vol. XXVII. Part 3. 8vo. 1864.
ervice Institution—Journal, Nos. 30, 31. 8vo. 1864.
zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Marz zu
ust, 1864. 4to.
mes, Esq. F.R.S. M.R.I.—Catalogue of the Melbourne Public Library.
1861.
l Society of London—Transactions. Vol. V. Part 3. 4to. 1864.
dings: 1863. 8vo.

GENERAL MONTHLY MEETING,

Monday, December 5, 1864.

AM POLE, Esq. M.A. F.R.S. Treasurer and Vice-President,
in the Chair.

John J. E. Mayall, Esq.
Charles Robinson, Esq.
Mrs. Harriet Scott,
George Tetley, Esq.
William James Thompson, jun. Esq.
Arnold White, Esq. and
Edward Williams, Esq.

ected Members of the Royal Institution.

Dádábhái Naoroji, Esq.

was *admitted* a Member of the Royal Institution.

The Chairman announced the following addition to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

Miss Harriet Moore (*2nd donation*)	£50 0 0

LECTURE ARRANGEMENTS FOR THE ENSUING SEASON:—

Christmas Lectures, 1864. (*Adapted to a Juvenile Auditory.*)

Prof. **FRANKLAND**, F.R.S.—Six Lectures, 'On the Chemistry of a Coal.'

Before Easter, 1865.

Prof. **TYNDALL**, F.R.S.—Twelve Lectures, 'On Electricity.'

Prof. **HOFFMANN**, F.R.S.—Six Lectures, 'An Introduction to the Study of Chemistry.'

Prof. **MASSON**.—Three Lectures, 'On Recent British Philosophy.'

CHARLES T. NEWTON, Esq.—Three Lectures, 'On Recent Acquisitions to the British Museum from Rhodes, and on the Statues from the Farnese Palace.'

Prof. **MARSHALL**, F.R.S.—Twelve Lectures, 'On the Nervous System in Man and Animals.'

After Easter.

Prof. **FRANKLAND**, F.R.S.—Twelve Lectures, 'On Organic Chemistry.'

Prof. **BAIN**.—Three Lectures, 'On the Physical Accompaniments of Mind.'

ALEXANDER HERSCHEL, Esq.—Three Lectures, 'On Meteorology: with more especial reference to the Laws of Storms and the System of Coast-Warning for the Prevention of Shipwrecks.'

M. **JULES SIMON**.—Three Lectures (*in French*), 'On the Physical and Moral Condition of Workmen.'

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

Registrar-General of Ireland—Weekly Return of Births and Deaths in Dublin. November, 1864. 8vo.

Russian Government—Annales de l'Observatoire Physique Central de Russie, 1860. 1861. 4to. 1864.

Asiatic Society of Bengal—Journal, No. 295. 8vo. 1864.

Astronomical Society, Royal—Memoirs. Vol. XXXII. 4to. 1864.

Beavan, Hugh J. C. Esq. (*the Editor*)—G. Pouchet: The Plurality of the Human Race. 8vo. 1864.

Belgique, Académie Royale de—Bulletin: Année 1863. 8vo.
Almanach, 1864. 16to.

Blackie, Professor J. S. (*the Author*)—The Gaelic Language. (K 91) 8vo. 1864.

British Architects, Institute of—Sessional Papers, 1864-5. Part 1. Nos. 1 and 2. 4to.

Chemical Society—Journal for November, 1864. 8vo.

Clausius, M. R. (*the Author*)—Abhandlungen über die Mechanische Wärmetheorie. 1ste Abtheilung. 8vo. Braunschweig, 1864.

Dublin Geological Society—Journal, Vol. X. Part 2. 8vo. 1864.
Editors—Artizan for November. 1864. 4to.
  Athenæum for November, 1864. 4to.
  Chemical News for November, 1864. 4to.
  Engineer for November, 1864. fol.
  Horological Journal for November, 1864. 8vo.
  Journal of Gas-Lighting for November, 1864. 4to.
  Mechanics' Magazine for November, 1864. 8vo.
  Medical Circular for November, 1864. 8vo.
  Pharmaceutical Journal for November, 1864.
  Practical Mechanics' Journal for November, 1864. 4to.
Franklin Institute of Philadelphia—Journal, No. 466. 8vo. 1864.
Geographical Society, Royal—Journal, Vol. XXXIII. 8vo. 1864.
Geological Society—Journal, No. 80. 8vo. 1864.
Greenwich Royal Observatory (*through the Royal Society*)—Greenwich Observations. 1862. 4to. 1864.
Kerr, Mrs. Alex. M.R.I.—L'Abbé Cochet: La Seine Inférieure, Historique et Archéologique. 4to. Paris, 1864.
Medico-Chirurgical Society, Royal—Transactions. Vol. XLVII. 8vo. 1864.
Newton, Messrs.—London Journal (New Series): November, 1864. 8vo.
Photographic Society—Journal, No. 151. 8vo. 1864.
Rey, M. Rodolph (*the Author*)—Turin, Florence ou Rome. (O 14) 12mo. 1864.
Royal Society of London—Proceedings, No. 68. 8vo. 1864.
Silliman, Professors (*the Editors*)—American Journal of Science, No. 114. 8vo. 1864.
Toronto Magnetic Observatory—Meteorological Abstracts and Results: 1854–62. 4to. 1864.
Upsala Royal Society of Sciences—Nova Acta, Series III. Vol. V. Fasc. 1. 4to. 1864.
  Upsala Universitets Arsskrift. 4to. 1863.
Yates, James, Esq. F.R.S. M.R.I. (*the Author*)—On a Volume containing Portions of Ptolemy's Geography, &c. (Trans. Roy. Soc. Lit. VIII.) 8vo. 1864.

1865.

WEEKLY EVENING MEETING,

Friday, January 20, 1865.

H.R.H. The Count of Paris, in the Chair.

Professor Tyndall, F.R.S. M.R.I.

On Combustion by Invisible Rays.

We are so accustomed to associate the word *ray* with the idea of light, that the term dark, or invisible, or obscure rays, stimulates the imagination by its strangeness; and such is more particularly the case wh we are told that the major portion of the radiation of the sun itself of this invisible character. This great discovery was announced sixty-five years ago by Sir William Herschel. Permitting a sun-beam to pass through a glass prism, he formed the coloured spectrum of the solar light; and, carrying a small thermometer through its various colours, he determined their heating power. He found this power to augment gradually from the violet to the red; but he also found that the calorific action did not terminate where the visible spectrum ended. Placing his thermometer in the dark space beyond the red, he proved the heating power there to be greater than in any part of the visible spectrum.

Sir William Herschel concluded from his experiments, that besides those rays which, acting separately upon the retina, produce the sensation of colour, and the sum of which constitutes our ordinary sunshine, a vast outflow of perfectly invisible rays proceeds from the sun, and that, measured by their heating power, the strength or energy of these invisible rays is greater than that of all the visible rays taken together.

This result was questioned by some and confirmed by others; but, like every natural truth that can be brought to the test of experiment, the verity of Sir William Herschel's announcement was soon completely established. Forty years after the discovery of those invisible rays by his father, Sir John Herschel made them the subject of experiment. He made an arrangement which enabled him to estimate the heating power of the spectrum by its *drying* power. Wetting by a wash of alcohol, paper blackened on one side, he cast his spectrum on this paper, and observed the chasing away of the moisture by the heat of the rays. His drying paper presented to him a *thermograph* of the spectrum and showed the heating power to extend far beyond the red.

By the introduction of the thermo-electric pile, Melloni created a new epoch in researches on radiant heat. This instrument enables us to examine, with a precision unattainable with ordinary thermometers, the distribution of heat in the solar spectrum. Melloni himself devoted some time to this subject. He had made the discovery that various substances, in the highest degree transparent to light, were eminently opaque to those invisible heat-rays. Pure water, for example, is a body of this kind. Only one substance did Melloni find to be equally pervious to the visible and the invisible rays—namely, transparent rock-salt. And though the researches of MM. De la Provostaye and Desains, together with some extremely suggestive experiments executed by Mr. Balfour Stewart, show conclusively that Melloni erred in supposing rock-salt to be *perfectly* transparent, it must be admitted that, in this respect, the substance approaches very near perfection.

Abandoning prisms of glass, which had been always employed previously, Melloni made use of a prism of rock-salt in his experiments on the solar spectrum. He was thus enabled to prove that the ultra-red rays discovered by Sir William Herschel formed an invisible spectrum, at least as long as the visible one. He also found the position of maximum radiant power to lie as far on one side the red as the green light of the spectrum on the other.

Dr. Franz, of Berlin, subsequently examined the distribution of heat in the solar spectrum, employing for this purpose a flint-glass prism. He showed that the inaction of the ultra-red rays upon the retina did not altogether arise from the absorption of those rays in the humours of the eye; at all events, he proved that a sensible portion of the invisible rays was transmitted across the eye-ball of an ox, and reached the back of the eye. Professor Müller, of Freiberg, afterwards examined very fully the heat of the solar spectrum; and representing, as Sir William Herschel also had approximately done, by lines of various lengths the thermal intensity at various points, he drew a curve which expressed the calorific action of the entire spectrum.

At various intervals during the last ten years the speaker had occupied himself with the invisible radiation of the electric light; and to the distribution of heat in its spectrum he now directed attention. The instruments made use of were the electric lamp of Duboscq and the linear thermo-electric pile of Melloni. The spectrum was formed by means of lenses and prisms of pure rock-salt. It was equal in width to the length of the row of elements forming the pile, and the latter being caused to pass through its various colours in succession, and also to search the space right and left of the visible spectrum, the heat falling upon it, at every point of its march, was determined by the deflection of an extremely sensitive galvanometer.

As in the case of the solar spectrum, the heat was found to augment from the violet to the red, while in the dark space beyond the red it rose to a maximum. The position of the maximum was about as disant from the extreme red in the one direction, as the green of the pectrum in the opposite one.

The augmentation of temperature beyond the red in the spectrum of the electric light is sudden and enormous. Representing the thermal ntensities by lines of proportional lengths, and erecting these lines as perpendiculars at the places to which they correspond, when we pass beyond the red these perpendiculars suddenly and greatly increase in ength, reach a maximum, and then fall somewhat more suddenly on he opposite side of the maximum. When the ends of the perpendicuars are united, the curve beyond the red, representing the obscure adiation, rises in a steep and massive peak, which quite dwarfs by its magnitude the radiation of the luminous portion of the spectrum.

Interposing suitable substances in the path of the beam, this peak may be in part cut away. Water, in certain thicknesses, does this very ffectually. The vapour of water would do the same; and this fact enables us to account for the difference between the distribution of heat n the solar and in the electric spectrum. The comparative height and teepness of the ultra-red peak, in the case of the electric light, are much greater than in the case of the sun, as shown by the diagram of Professor Müller. No doubt the reason is, that the eminence correponding to the position of maximum heat in the solar spectrum has been cut down by the aqueous vapour of our atmosphere. Could a solar spectrum be produced beyond the limits of the atmosphere, it would probably show as steep a mountain of invisible rays as that exhibited by the electric light, which is practically uninfluenced by atmospheric absorption.

Having thus demonstrated that a powerful flux of dark rays accompanies the bright ones of the electric light, the question arises, "Can we not detach the former and experiment on them alone?"

One way of doing this would be to cut off the luminous portion of the decomposed beam by an opaque screen, allowing the non-luminous portion to pass by its edge. We might then operate at pleasure upon the latter:—reflect it, refract it, concentrate it. This, in fact, was done by Sir William Herschel, but a quantity of heat could not thus be obtained sufficient to produce the results intended to be exhibited before the conclusion of the discourse. Another plan consists in permitting the total radiation to pass through some substance transparent to the heat rays, but opaque to the light rays. Melloni discovered that lampblack, and also a kind of black glass, while perfectly opaque to light, transmitted a considerable quantity of radiant heat. In the "Lectures on Heat," given at the Royal Institution in 1862, and since made public, experiments with these bodies are described. It was while conversing with his friend Mr. Warren De la Rue, in the autumn of 1861, on the possibility of sifting, by absorbents, the light of a beam from its heat, that the speaker first learned that carbon was the substance which rendered Melloni's glass opaque. This fact was of peculiar interest to him, for it and others seemed to extend to solid bodies a law which he had detected two years previously in his experiments on gases and vapours, and which showed that *elementary* gases were highly transparent, while *compound* gases were all more or less opaque—many of them, indeed, almost perfectly opaque—to invisible radiant heat.

In the speaker's first experiments on the invisible radiation of the electric light, black glass was the substance made use of. The specimens, however, which he was able to obtain destroyed, along with the visible, a considerable portion of the invisible radiation.* But the discovery of the deportment of elementary gases directed his attention to other simple substances. He examined sulphur dissolved in bisulphide of carbon, and found it almost perfectly transparent to the invisible rays. He also examined the element bromine, and found that notwithstanding its dark colour, it was eminently transparent to the ultra-red rays. Layers of this substance, for example, which entirely cut off all the light of a brilliant gas flame, transmitted its invisible radiant heat with freedom. Finally, he tried a solution of iodine in bisulphide of carbon, and arrived at the extraordinary result, that a quantity of dissolved iodine sufficiently opaque to cut off the light of the mid-day sun was, within the limits of experiment, absolutely transparent to invisible radiant heat.

---

* The glass in thin layers had a greenish hue: I have since found black glass far more diathermic.—J. T.

This then is the substance by which the invisible rays of the electric light may be almost perfectly detached from the visible ones. Concentrating by a small glass mirror, silvered in front, the rays emitted by the carbon points of the electric lamp, we obtain a convergent cone of light. Interposing in the path of this concentrated beam a cell containing the opaque solution of iodine, the light of the cone is utterly destroyed, while its invisible rays are scarcely, if at all, meddled with. These converge to a focus, at which, though nothing can be seen even in the darkest room, the following series of effects may be produced:—

When a piece of black paper is placed in the focus, it is pierced by the invisible rays, as if a white-hot spear had been suddenly driven through it. The paper instantly blazes, without apparent contact with anything hot.

A piece of brown paper placed at the focus soon shows a red-hot, burning surface, extending over a considerable space of the paper, which finally bursts into flame.

The wood of a hat-box similarly placed, is rapidly burnt through. A pile of wood and shavings, on which the focus falls, is quickly ignited, and thus a fire may be set burning by the invisible rays.

A cigar or a pipe is immediately lighted when placed at the focus of invisible rays.

Disks of charred paper placed at the focus are raised to brilliant incandescence; charcoal is also ignited there.

A piece of charcoal, suspended in a glass receiver full of oxygen, is set on fire at the focus, burning with the splendour exhibited by this substance in an atmosphere of oxygen. The invisible rays, though they have passed through the receiver, still retain sufficient power to render the charcoal within it red-hot.

A mixture of oxygen and hydrogen is exploded in the dark focus, through the ignition of its envelope.

A strip of blackened zinc-foil placed at the focus is pierced and inflamed by the invisible rays. By gradually drawing the strip through the focus, it may be kept blazing with its characteristic purple light for a considerable time. This experiment is particularly beautiful.

Magnesium wire, presented suitably to the focus, burns with almost intolerable brilliancy.

The effects thus far described are, in part, due to chemical action. The substances placed at the dark focus are oxidizable ones, which, when heated sufficiently, are attacked by the atmospheric oxygen, ordinary combustion being the result. But the experiments may be freed from this impurity. A thin plate of charcoal, placed *in vacuo*, is raised to incandescence at the focus of invisible rays. Chemical action is here entirely excluded. A thin plate of silver or copper, with its surface slightly tarnished by the sulphide of the metal, so as to diminish its reflective power, is raised to incandescence either *in vacuo* or in air. With sufficient battery-power and proper concentration, a plate of platinized platinum is rendered white-hot at the focus of invisible rays; and when the incandescent platinum is looked at through a prism, its light yields a complete and brilliant spectrum. In all these cases we have, in the first place, a perfectly invisible image of the coal points formed by the mirror; and no experiment hitherto made illustrates the identity of light and heat more forcibly than this one. When the plate of metal or of charcoal is placed at the focus, the invisible image raises it to incandescence, and thus prints itself visibly upon the plate. On drawing the coal points apart, or on causing them to approach each other, the thermograph of the points follows their motion. By cutting the plate of carbon along the boundary of the thermograph, we might obtain a second pair of coal points, of the same shape as the original ones, but turned upside down; and thus by the rays of the one pair of coal points, which are incompetent to excite vision, we may cause a second pair to emit all the rays of the spectrum.

The ultra-red radiation of the electric light is known to consist of ethereal undulations of greater length, and slower periods of recurrence, than those which excite vision. When, therefore, those long waves impinge upon a plate of platinum, and raise it to incandescence, their period of vibration is changed. The waves emitted by the platinum are shorter and of more rapid recurrence, than those falling upon it; the refrangibility being thereby raised, and the invisible rays rendered visible. Thirteen years ago, Professor Stokes proved that by the agency of sulphate of quinine, and various other substances, the ultra-violet rays of the spectrum could be rendered visible. These invisible rays of high refrangibility, impinging upon a proper medium, cause the molecules of that medium to oscillate in slower periods than those of the incident waves. In this case, therefore, the invisible rays are rendered visible by the *lowering* of their refrangibility; while in the experiments of the speaker, the ultra-red rays are rendered visible by the *raising* of their refrangibility. To the phenomena brought to light by Professor Stokes, the term *fluorescence* has been applied by their discoverer, and to the phenomena brought forward this evening at the Royal Institution, it was proposed to apply the term *calorescence*.

It was the discovery, more than three years ago, of a substance opaque to light, and almost perfectly transparent to radiant heat—a substance which cut the visible spectrum of the electric light sharply off at the extremity of the red, and left the ultra-red radiation almost untouched, that led the speaker to the foregoing results. They lay directly in the path of his investigation; and it was only the diversion of his attention to subjects of more immediate interest that prevented him from reaching, much earlier, the point which he has now attained. On this, however, he can found no claim; and the *idea* of rendering ultra-red rays visible, though arrived at independently, does not by right belong to him. The right to a scientific idea or discovery is secured by the act of publication; and, in virtue of such an act, priority of conception as regards the conversion of at-rays into light-rays belongs indisputably to Dr. Akin. At the eeting of the British Association, assembled at Newcastle in 1863, proposed three experiments by which he intended to solve this estion. He afterwards became associated with an accomplished man science, Mr. Griffith of Oxford, and jointly with him pursued the quiry. Two out of the three experiments proposed at Newcastle by r. Akin are impracticable. In the third, Dr. Akin proposed to onverge the rays of the sun by a concave mirror, to cut off the ght by 'proper absorbents,' and to bring platinum foil into the focus invisible rays. It is quite possible, that, had he possessed the instruental means at the speaker's disposal, or had he been sustained as the eaker had been both by the Royal Society and the Royal Institution, r. Akin might have been the first to effect the conversion of the dark at-rays into luminous ones. For many years the idea of forming intense focus of invisible rays had been perfectly clear before e speaker's mind; and in 1862 he published experiments upon e subject. The effects observed by him in 1862 at the focus invisible rays were such as no previous experimenter had itnessed, and no experimenter could have observed them without ing driven to the results which formed the subject of the evening's scourse. Still publication is the sole test of scientific priority; and it nnot be denied that Dr. Akin was the first to propose definitely to ange the refrangibility of the ultra-red rays of the spectrum, by using them to raise platinum foil to incandescence.

[J. T.]

WEEKLY EVENING MEETING,

Friday, January 27, 1865.

r Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President,
in the Chair.

Major-General Sir Henry C. Rawlinson, K.C.B. D.C.L. F.R.S.

On the results of Cuneiform Discovery up to the present time.

r Henry commenced by observing that the time had gone by when was necessary to defend the system of Cuneiform Decipherment om the attacks of the incredulous. The school of sceptics, led on the late Sir G. Lewis and his friends, had passed away. France d Germany, which were at first slow to believe, had now fairly given their adhesion, and admitted Assyrian studies into the recognized tegory of linguistic science. The Institute of France, indeed, had t year conferred its biennial prize of 20,000 francs on M. ppert, for his labours on the Assyrian Inscriptions, thereby testifying, the face of Europe, to the genuineness and value of his researches.

In England, the Cuneiform decipherers were no longer looked upon as visionaries or impostors. The tone of the public press had become, at any rate, respectful, and anxiety was beginning to be shown for authentic information on the subject.

Assuming, then, that there was no occasion to recapitulate the arguments, which he had advanced in a former discourse in that room, in support of the general principles of his method of Decipherment. Sir Henry went on to say, that great caution was still required to be exercised in discriminating between guess-work and demonstration, and in accepting the results put forward by different enquirers. M. Oppêrt, for instance, had contributed an article on the "Tower of Babel," to Dr. Smith's "Dictionary of the Bible," asserting that the name of Borsippa, which attached to the site where the tower was traditionally believed to have stood, was etymologically connected with "the confusion of tongues," and that there was also a distinct allusion to the same event in the inscription on the cylinders found in the ruins of the Borsippa Temple; and this remarkable notice, transferred to the pages of a recent number of the "Quarterly Review," had naturally attracted much attention amongst Biblical students, authenticating, as it seemed to do, one of the earliest and most important portions of the Scripture narrative. There was in reality, however, no foundation whatever for M. Oppêrt's statement. He had misinterpreted certain expressions, and at once jumped to the conclusion that he had really found a trace of Noachidan history. As far as Sir Henry's own researches extended, not a single allusion had been discovered in the inscriptions, either of Assyria or Babylonia, to the leading events of the Mosaic record. It seemed probable, indeed, that the earliest native Babylonian notices did not reach as high as the period of Chedorlaomer and his confederate kings; for at that time Elam was evidently in the ascendant, and the provinces to the westward were mere tributaries, whereas when Cuneiform history first dawns on us, we find the Turanian tribes of the Accad and their allies, represented in the Bible by the *goim*, or "nations," of whom Tidal (properly, *Tur-gal*, "the great chief") was king, exercising independent sway in Southern Chaldea.

Sir Henry then, referring to diagrams suspended on the wall, proceeded to explain his own views with regard to the early comparative chronology of Assyria and Babylonia, as revealed to us from the Cuneiform Inscriptions. He showed, in the first place, that there was an authentic date reaching as high as the 19th century B.C. Whether the *Ismi-dagon*, who built a temple in Assyria at this period, was really the king of the same name, whose bricks had been found in the ruins of Ur of the Chaldees, did not much signify. It was sufficient to know that the Assyrians really had materials for history, ascending to a period of such remote antiquity. He believed himself, that the Assyrian "Empire," succeeding the rule of the high-priests, commenced in the 18th century B.C. synchronously, perhaps, with the establishment of a Turanian dynasty in Babylon. To the latter.

on the authority of Berosus, he assigned a duration of 450 years, supposing that in about B.C. 1300, Tilgamus of Assyria had driven out these Turanians, and established a junior branch of the Royal family of Nineveh on the throne of Babylon, which family had remained in power until shortly before the era of Nabonassar in B.C. 747. The great line of Assyrian royalty had, probably, remained unbroken from the first establishment of the Empire in the 18th century B.C. to the death of Shalmaneser IV. at the siege of Samaria, in B.C. 721, and the remaining kings, from Sargon downwards, who, if belonging to the royal family, did not, at any rate, succeed in the direct line of hereditary descent, formed what was generally called the Lower dynasty.

A most important aid for determining the dates of the later Assyrian history, and for rectifying, by means of these dates, the general scheme of Scripture chronology, had been recently obtained, through the discovery, among the Nineveh tablets in the British Museum, of a table of Archons, or Eponymes, extending over a period of 270 years. It had been the custom at Nineveh, as at Athens, to name the year after a particular officer, and a series of these names, therefore, formed an official chronological table. Fragments of four such tables had been found, the reigns of the kings, moreover, being marked by a line drawn across the column of names, and students were thus able within the limits of the series, or from about B.C. 910 to 640, to determine he relative date of all the leading events in the history of Western Asia. The effect of this was to lower the date of Jehu and his con-emporaries by about forty years.

Sir Henry then went on to show from a diagram, explaining the canon, the various synchronisms of Assyrian and Jewish history, down to the time of the great Sardanapalus, who was, he stated, the son of he Biblical Esar-Haddon. The reign of Sardanapalus afforded the only point of contact between the history of Nineveh and the history of Greece, the Assyrian empire expiring just as the Grecian power arose. The dodecarchy of Egypt, described by Herodotus, was shown to have been instituted by Sardanapalus, and the same king received an offer-ng of Cimmerian slaves from Gyges, the king of Lydia, who played o prominent a part both in Grecian history and fable.

In a later part of his discourse, Sir Henry commented on the contents of many of the tablets which he had been recently examining,* and of which the following was a list :—

1. Syllabaries, or lists, explaining the phonetic powers and meanings of all the Assyrian simple and compound characters and monograms.

---

* These "terra-cotta" tablets, which form the most valuable portion of the Assyrian collection in the British Museum, were exhumed from the ruins of the alace of Sardanapalus at Nineveh, being in fact the debris of the Royal Library. There are probably as many as 100,000 fragments of such tablets now ranged on he shelves of our national museum, but a very small portion are legible, and a till smaller portion sufficiently perfect to give the sense of the document to which hey belong.

These lists were invaluable, he said, to the Assyrian student, and comprised above one thousand characters.

2. Grammatical documents, explanatory of the old Babylonian language, which was itself of the Turanian type, and yet was largely, though irregularly, amalgamated with the Semitic Assyrian.

3. Classified lists of animals and birds, of woods, metals, stones, trees, fruits, and all natural productions, the lists being arranged in the two languages of Assyria and Babylon.

4. Mythological treatises, giving the names, parentage, functions, and attributes of the gods; the places where they were worshipped: specific names of the temples; the prayers and sacrifices to be addressed to them; their festivals, &c., &c. There were only thirteen principal divinities worshipped in Assyria, but the minor members of the Pantheon were "Legion."

5. Explanatory lists of proper names, showing the principles on which the system of Assyrian nomenclature was based. Every name in Assyrian had thus a distinct meaning: Sennacherib meant "The moon glorifies my brothers;" Merodach-Baladan, "Merodach has given a son;" Nebuchadnezzar, "Nebo is the protector of landmarks;" Sargon, "The established king;" Esar-Haddon, "Asshur has given a brother," &c., &c.

6. Legal documents, consisting of deeds of sale of lands, houses, gardens, orchards, vineyards, slaves, cattle, grain, &c.; leases of property or grants for a term of years, on special conditions of farming and taxation; contracts for the supply of grain; purchases of grain, or farm stock, or other property; loans of money (calculated by weight in silver) at interest, and often on security of land, or cattle, or grain; deeds of barter; dedication of slaves to the service of the temples, &c. &c. Sir Henry said he had copied some hundreds of these legal tablets, and had thus acquired a very tolerable insight into the private life of the Assyrians. These legal documents, like the others, had been inscribed, in the first instance, on tablets of soft clay, which were afterwards baked and converted into "terra cotta." Before the tablet, however, was put into the furnace, the executing party—that is, the person conveying his property to another set his seal to it, to authenticate the transfer; and, in default of a seal, he made three or more impressions with his thumb nail, the said impressions enabling one at the present day to recognize the exact fashion in which the Assyrians cut their nails. On the margin of all such tablets there was a memorandum, charging an extra fee to the law officer for using the thumb nail instead of the seal, apparently as a punishment for carelessness in not wearing the regular signet seal. These legal documents were usually executed somewhat after the following form:—First, the name and office of the party or parties conveying their property, underneath the seals of such parties authenticating the conveyance; then the statement of property, lands, houses, slaves, or other chattels to be sold; then the name and quality of party or parties buying; price in weight of silver; money to be paid in full; property to be taken possession

uyer ; contract to be final and lasting ; if the seller refuse to
ontract, liable to severe penalty ; fine to be paid to the gods ;
se-money to be returned tenfold to the buyer, and contract to
lared cancelled. Then follow the names of witnesses, who some-
lso set their seals to the document—and at the end the date of
e, that is, day, month, and year of Eponyme or Archon ; and,
name of law officer, or *Aba*, who drew up the contract. Among
gal documents were some which resembled our marriage-settle-
an Assyrian young lady, as it appeared, not being entitled to
roperty in her own name after marriage, but a trustee being
ted by the father to hold the lands for her separate use.

. 7, was a class of tablets, which Sir Henry could only compare
visiting cards, or rather to the practice of writing one's name in
sitor's book at Buckingham palace or Marlborough house.
ontained simply the name of the visitor, calling himself "the
slave," and an invocation to the gods to protect the monarch,
ey seemed to have been left at the king's palace as a mere mark
ectful loyalty. Their only value now was as an evidence of an
t curious custom, and as a means of accumulating Assyrian

Despatches and letters from officers on service reporting victories
he king's enemies, and giving elaborate lists of killed and
ed, captives, amount of spoil, &c. From these documents were
uently compiled the official annals of the monarch.

Inventories of the royal property, deposited in the different
of the kingdom. The objects were often difficult of identifica-
ut the lists were still very curious.

Records of hunting expeditions ; in fact, a sort of royal game-
kept by the "grand veneur," the game, however, being chiefly
nd leopards, and the larger wild animals.

Agricultural treatises, explaining all the various details of hus-
in relation to the best time and method of cultivating corn and
land. These contained many very curious details about sowing,
g. manuring, succession of crops, &c.

. 12 comprised astronomical and astrological documents. Sir
stated that he was at present busily engaged in investigating the
of this class ; and he trusted that when he had finished his
hes, he should be able to trace the progress of astronomy
he first glimmerings of the pursuit amongst the Chaldeans, with
it was well known to have originated, to the more perfect state
ch the science was handed over by the Chaldeans to the Greeks,
by them transmitted to the Arabs, and, through their means,
oduced into Europe during the dark ages. It was a very dif-
study, and his investigations were as yet incomplete ; but still he
ready obtained results which filled him with extreme surprise,
only were the Assyrians acquainted with the general movement
heavenly bodies, and with the laws and tables necessary to
them to calculate lunar eclipses, but they also seemed to have

observed the four satellites of Jupiter, which, in those regions, could be often seen with the naked eye, and to have been even acquainted with the seven satellites of Saturn, which never could have been seen without the aid of lenses. He had also found a notice of comets, and many allusions to eclipses. What he was now especially searching for was a register of lunar eclipses, dated from the year of the Eponyme or Archon, similar to that register, in fact, which must have been consulted by Ptolemy in compiling the Almagest; for it must be remembered that if the exact date of a single Eponyme or Archon could once be fixed by an astronomical calculation, then the whole of the 270 years of the canon would at once become positive chronology; since the name of one single Archon would regulate the entire series. He had also found a large number of observatory reports on the full moon and the equinoxes, and tables for the position of the planets throughout the year. The great majority of the tablets, however, of which he was now treating, referred to astrology, and recorded the pretended influence of the heavenly bodies—as they were in conjunction or opposition—upon all sublunary actions; everything being included, as in "Zadkiel's Almanac" and similar trash of the present day, from the fate of empires to washing one's hands or paring one's nails. There were also horoscopes and nativities and hemerologies, giving the lucky and unlucky days throughout the year. The whole system, indeed, of judicial astrology and magic had originally come, as was well known, from Chaldea; and he was now examining the very documents which had so well bewildered and fascinated the Greek philosophers. Among the fragments of real science, which he hoped to extract from the mass of rubbish now under investigation, were an explanation of the original solar zodiac, a list of the fixed stars known to those primitive astronomers, and, possibly, some evidence as to their invention of the lunar zodiac, or "mansions of the moon," which had been also known in extreme antiquity both to the Chinese and Indians.

Sir Henry said that, before concluding, he would quote a few instances in which the accuracy of his system of cuneiform decipherment had been tested; and he would leave his audience to judge from the results, if they were not fully warranted in accepting his translations.

1. Sir Gardner Wilkinson, many years ago, had found a porphyry vase in the treasury of St. Mark's at Venice, inscribed with a legend both in hieroglyphics and in cuneiform. He sent a copy of the cuneiform legend to Sir Henry, who at once read it as "Artaxerxes, the great king," the very same reading having been already obtained by Sir Gardner from the hieroglyphs.

2. A similar test was afforded by the legend found on the vase excavated by Mr. Newton a few years back from the famous tomb of Mausolus at Halicarnassus Mr. Birch, the great Egyptologist, read the hieroglyphic legend as "Xerxes, the great king," and Sir Henry independently furnished the same reading for the cuneiform.

3. A more elaborate test was subsequently undertaken. Copies of

the great cylinder inscription of Tiglath-Pileser I., extending to nearly 1000 lines of cuneiform writing, were submitted to four Assyrian scholars—to Sir Henry in London, to Dr. Hincks in Ireland, to M. Oppert in Paris, and to Mr. Fox Talbot of Laycock Abbey, and they were invited to send in independent translations under seal, on a certain day, to be examined by a committee composed of the first scholars in England, namely, Dean Milman, Mr. Grote, the historian, Professor Wilson, Dr. Cureton, and Sir Gardner Wilkinson. The translations were thus sent in to the committee, and on being compared were found to coincide, not indeed word for word, but in all essentials of distribution of subject, reading of names, and general signification, the verdict recorded by the committee being decisive as to the competency of the gentlemen engaged to read and translate the language.

4. A further means of verification had been afforded by a series of bi-lingual readings—cuneiform and Phœnician—recently discovered on some of the Nineveh legal tablets. These tablets, which contained for the most part deeds of sale in cuneiform, were docketed in Phœnician, and the names of the parties expressed in the two languages corresponded throughout, as had been shown in a paper recently published by Sir Henry on the subject.

5. The last proof he should give was still more curious. He had met with a passage in one of the Nineveh inscriptions, which stated that the king Asshur-izir-pal (the famous builder of the North-West Palace at Nimrûd, excavated by Mr. Layard), having reached the sources of the Tigris in one of his mountain expeditions, had there found the memorial tablet of Tiglath-Pileser I., sculptured with his image and titles; and had accordingly, in imitation of his great predecessor, sculptured his own figure and titles on the rock as a "pendant" to the other tablet. Sir Henry, being much struck with this curious passage, had requested Mr. John Taylor, H.M. Consul at Diyarbekir, who was then travelling in the vicinity, to take an opportunity of visiting the source of the Tigris, and thus verifying the Nineveh notice. Mr. Taylor did visit the spot in the course of his travels, and there, on the walls of a cave from which the main stream of the Tigris flows, he found the two tablets precisely as described in the annals of the Nineveh king. He had sent home casts in paper, both of the sculpture and inscriptions, which had been published in the second volume of Professor Rawlinson's (a brother of the speaker) "Ancient Monarchies." The sculpture of Tiglath-Pileser I., dated from the twelfth century B.C., and was the earliest specimen of Assyrian Art yet discovered. Sir Henry thought that, after such repeated instances of verification, no reasonable doubt could be entertained of the correctness of the cuneiform readings.

Sir Henry said, in conclusion, that he wished to draw the attention of the public to the curious treasure-house of old-word knowledge into which he was seeking to penetrate. It was not to be expected that, however successful future researches might be, anything of real importance could be added from the Nineveh tablets to the scientific knowledge of the nineteenth century; but still it could hardly be devoid of interest to ascertain the social and intellectual condition of the Assyrians at such an early period of history, intimately connected as those people were, on the one side, with the Jews in laws, language, and religion, and standing as they did, on the other side, in the position of progenitors of European civilization; for it could not now be doubted that the Asiatic Greeks derived their first germs of art, of philosophy, and of Science from the Chaldeans and Assyrians.

He could not hold out the prospect of any great results from the materials now in hand, for the tablets were, for the most part, crumbling and mutilated; and he doubted, moreover, if the original Nineveh collection had ever contained documents of the highest class of interest, —such as codes of laws, or systems of philosophy, or even those astronomical registers, involving abstruse mathematical calculations, which had excited the admiration of Aristotle when forwarded by Calisthenes from Babylon; but still he did not despair of more successful discoveries hereafter. At present, they had merely access to a single collection of literary documents belonging to a single king; but, no doubt, every city in the old empires of Babylonia and Assyria had its library, and every monarch had his record office; and there was nothing therefore unreasonable in hoping that Arbela, or *Nebi-Junus*, or *Kileh Shergat* in Assyria, or some of the still more ancient sites in Southern Chaldea, which had been as yet but most imperfectly explored, would some day yield up more perfect and more valuable treasures.

Sir Henry added, that our excavating labours were limited at present to one experimental search, which was being made by Colonel Kemball, our consul-general in Turkish Arabia, among the little-visited Chaldean ruins, in connection with his duty of superintending the construction of the overland telegraph between Bagdad and Bussorah. As Colonel Kemball had no more than 500*l.* at his disposal for excavating purposes, he could do little beyond tapping the soil in the various sites selected for examination; but still every new brick and every new fragment of a tablet added something to our previous stock of knowledge; and there was reason, at any rate, to be thankful that some movement had been thus renewed; that we were not, in fact, reduced to that total cessation from all progress—that "rest and be thankful" condition—which had recently found favour in high quarters; but which, in his humble opinion, was as fatal to science as it was to liberty.

[H. C. R.]

WEEKLY EVENING MEETING,

Friday, February 3, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President,
in the Chair.

William Odling, M.B. F.R.S.

On Aluminium Ethide and Methide.

The symbols by which the atomic proportions of a few of the principal metallic elements are usually represented, together with the relative weights of these several proportions, are shown in the following table:—

Lithium	Li	7
Magnesium	Mg	24
Zinc	Zn	65
Arsenic	As	75
Silver	Ag	108
Tin	Sn	118
Mercury	Hg	200
Lead	Pb	207
Bismuth	Bi	210

It is observable that the atomic proportions of the metals range from 7 parts of lithium, through 108 parts of silver up to 210 parts of bismuth. Now it is found that all these different proportions have substantially the same specific heat, so that 7 parts of lithium, 108 parts of silver, and 210 parts of bismuth, for instance, absorb or evolve the same amount of heat in undergoing equal increments or decrements of temperature. Hence, taking silver as a convenient standard of comparison, the atomic proportion of any other metal may be defined to be, that quantity of the metal which has the same specific heat as 108 parts of silver.

Many of the metals unite with the halogen radicles chlorine and bromine, as also with the organic radicles ethyl and methyl, to form volatile compounds, which may be conveniently compared with the chloride and ethide of hydrogen. Now, it is found that the several proportions of metal or hydrogen contained in equal volumes of these gaseous chlorides or ethides, are their respective atomic proportions; so that equal volumes of chloride or ethide of hydrogen, zinc, arsenic, tin, mercury, lead, and bismuth, for instance, contain 1, 65, 75, 118, 200, 207, and 210 parts of hydrogen or metal respectively. Hence, the molecule of chloride of hydrogen, HCl, being conventionally regarded as constituting two volumes, the atomic proportion of a metal may be defined to be that quantity of the metal which is contained in two volumes of its gaseous chloride, or bromide, or ethide, or methide, &c.

These two definitions having reference respectively to the specific heats of the metals, and the molecular volumes of their gaseous compounds, lead in all cases to the same conclusion. Thus, 200 parts of mercury is the quantity of mercury which has the same specific heat as 108 parts of silver, and is also the quantity of mercury contained in two volumes of mercuric chloride, mercuric ethide, &c.

The atomic proportions of the different metals unite with 1, 2, 3, 4, &c. atoms of chlorine and ethyl, to form the two-volume molecules of their respective chlorides and ethides, as shown below :—

2 Vols.	2 Vols.	2 Vols.
$H\ Cl$	$H\ Et$	,,
$HgCl_2$	$HgEt_2$	$ZnEt_2$
$Bi\ Cl_3$	$Bi\ Et_3$	$AsEt_3$
$Sn\ Cl_4$	$Sn\ Et_4$	$PbEt_4$

Or, two volumes of the gaseous chlorides of hydrogen, mercury, bismuth, and tin, for instance, are found to contain respectively 35·5 parts, twice 35·5 parts, three times 35·5 parts, and four times 35·5 parts of chlorine.

Aluminium, which is one of the three most abundant constituents of the earth's crust, and the most abundant of all its metallic constituents, enters into the composition of a large number of native minerals of great value in the fine and useful arts, and also forms extremely well-defined artificial compounds, possessing a high degree of chemical interest. Nevertheless chemists are not at all agreed as to the atomic weight which should be accorded to the metal, or as to the molecular formulæ of its principal compounds.

The quantity of aluminium which has the same specific heat as 108 parts of silver, is found to be 27·5 parts; and analysis shows that this quantity of aluminium combines with three times 35·5 parts of chlorine to form chloride of aluminium. Accordingly the atomic proportion of aluminium should be fixed at 27·5 parts; its chloride be formulated as a trichloride thus, $AlCl_3$; and its other compounds be represented by corresponding expressions, as shown in the left-hand column of the following table, instead of by the heretofore used more complex expressions shown in the right-hand column :—

Al 27·5		Al 13·75
$AlCl^3$	Chloride	Al_2Cl_3
$Na\ AlCl_4$	Sodio-Chloride	$Na\ Al_2Cl_4$
Na_3AlF_6	Cryolite	$Na_3Al_2F_6$
Na_3AlO_3	Aluminate	$Na_3Al_2O_3$
$H\ AlO_2$	Diaspore	$H\ Al_2O_2$
$K\ AlS_2O_8$	Alum	$K\ Al_2S_2O_8$
$K\ AlSi_3O_8$	Feldspar	$K\ Al_2Si_3O_8$
$P\ AlO_4$	Phosphate	$P\ Al_2O_4$

the quantity of aluminium contained in two volumes of its
chloride was found by Deville to be 55 parts, instead of
rts, while the quantity of chlorine was found to be *six* times
rts, instead of *three* times 35·5 parts. Hence, relying ex-
y upon molecular volume, the atomic weight of aluminium
e 55, and the formula of chloride of aluminium $AllCl_6$. This
ion, however, is inadmissible for several reasons, and chiefly
it would make the atomic proportion of aluminium possess a
heat twice as great as that belonging to the atomic proportion
other metal.

evade this difficulty some chemists have proposed to accord to
ecule of aluminic chloride the formula Al_2Cl_6, whereby an indi-
proportion of metal would be habitually represented by a divi-
ymbol; for it is agreed on all hands that the proportion of
um contained in the molecule of aluminic chloride is the
proportion of aluminium found in any aluminic compound
ver; that it is incapable of experimental division by any pro-
atsoever; and consequently that, so far as our present know-
oes, it is an indivisible or atomic proportion.

v there are undoubtedly certain bodies, elementary and com-
of which the ascertained vapour densities, and consequent
s, no matter how accounted for, are, as a mere matter of
ent, discordant with the chemical analogies of the respective
but in most instances these anomalous results are rendered
rtant by other determinations of vapour density, either of the
odies raised to higher temperatures, or of associated bodies
a more decided volatility. Hence arises the question whether
ertained volume of aluminic chloride, which is discordant with
cific heat of aluminium, may not be anomalous in a similar
, and whether the anomaly may not be corrected by an examin-
other more volatile aluminic compounds.

methide and ethide of aluminium recently obtained by
ckton and the speaker are, so to speak, varieties of aluminic
in which the chlorine has been replaced by methyl and ethyl,
at the same time far more volatile and manageable than
cal chloride. Now, it has been found that two gaseous volumes
methide and ethide of aluminium contain only 27·5 parts of
um, united with three atomic proportions of methyl and ethyl;
ordingly their molecules have to be expressed by the formulæ
and $AlEt_3$ respectively. In other words, the normal results
l with the methide and ethide correct the anomalous result
l with the chloride, and confirm the atomic weight and
lar formulæ deducible from the specific heat of aluminium.

t the ascertained vapour density of aluminic chloride is really
us receives a further corroboration in the behaviour of
c methide itself. At 220°, and all superior temperatures, the
density of this compound shows that two volumes of its
contain 27·5 parts of aluminium and *three* times 15 parts of

methyl; but at 130°, its vapour density, corrected for alteration of temperature, becomes very nearly doubled, or, in other words, two volumes of its vapour contain very nearly 55 parts of aluminium and *six* times 15 parts of methyl. According, however, to the well-known rule, based on the separate researches of Cahours and Deville, the molecular formula of a body must be calculated from its permanent or ultimate, and not from its variable or initial vapour density, whence the high vapour density of aluminium methide at 130° does not at all interfere with our attributing to its molecule the formula $AlMe_3$, deducible from its vapour density at 220° and upwards, and harmonizing with the specific heat of metallic aluminium.

Aluminium ethide and methide occur as colourless liquids. The ethide boils at 194°, and does not freeze at − 18°. The methide boils at 130°, and solidifies at a little above 0° into a beautiful crystalline mass. Both liquids take fire on exposure to air, and explode violently by contact with water. They are produced from mercuric ethide and methide respectively, by heating these compounds for some hours in a water-bath, with excess of aluminium clippings. This process was obviously suggested by Frankland and Duppa's new reaction for making zinc ethide, methide, amylide, &c.

$$Al_2 \quad + \quad 3\,HgEt_2 \quad = \quad Hg_3 \quad + \quad 2\,AlEt_3.$$

[W.O.]

GENERAL MONTHLY MEETING,

Monday, February 6, 1865.

WILLIAM POLE, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Countess of Tankerville.
Francis Woodhouse Braine, Esq.
James Brogden, Esq.
William Henry Harrison, Esq.
Thomas Lucas, Esq.
John Lambert Mears, Esq.
William Miller, Esq.
James Romanes, Esq.
Edward Young Western, Esq. and
Henry Westropp, Esq.

were *elected* Members of the Royal Institution.

The Special Thanks of the Members were returned for a Legacy of £100 from the late George Dodd, Esq. (the legacy duty having been paid by Mrs. Dodd), for the fourth annual Donation of Five guineas from Mrs. Barlow, and to the respective donors of the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

	£	s.	d.
The Rev. John Barlow (*2nd donation*)	10	0	0
Henry Vaughan, Esq.	21	0	0
Edmund Packe, Esq.	5	5	0

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Actuaries, Institute of—Assurance Magazine. No. 58. 8vo. 1865.

Astronomical Society, Royal—Monthly Notices, 1864-5. Nos. 1, 2. 8vo.

Bavarian Academy of Sciences, Royal—Sitzungsberichte. 1864: I. 3, 4, 5. II. 1, 2. 8vo.

British Architects, Royal Institute of—Sessional Papers. 1864-5. II. 1. 4to.

Cambridge Observatory, Syndicate—Astronomical Observations, 1855-60. 4to. 1864.

Chalmers, James, Esq. (*the Author*)—Naval Armour. (K 91) 8vo. 1865.

Chemical Society—Journal for December, 1864. 8vo.

Davy John, M.D. F.R.S. (*the Author*)—Letters [respecting Mr. Babbage's Charges against Sir H. Davy.] (K 91) 8vo. 1864.

Editors—Artizan for December, 1864, and January, 1865. 4to.
  Athenæum for December, 1864, and January, 1865. 4to.
  Chemical News for December, 1864, and January, 1865. 4to.
  Engineer for December, 1864, and January, 1865. fol.
  Horological Journal for December, 1864, and January, 1865. 8vo.
  Journal of Gas-Lighting for December, 1864, and January, 1865. 4to.
  Mechanics' Magazine for December, 1864, and January, 1865. 8vo.
  Medical Circular for December, 1864, and January, 1865. 8vo.
  Pharmaceutical Journal for December, 1864, and January, 1865.
  Practical Mechanics' Journal for December, 1864, and January, 1865. 4to.

Geographical Society, Royal—Proceedings. Vol. IX. No. 1. 8vo. 1865.

Geological Institute, Vienna—Jahrbuch: 1864. Nos. 2, 3. 8vo.

Geological Survey of India—Memoirs: Vol. III. Part 2. Vol. IV. Part 2. 8vo. 1864. Report, Eighth year. 1863-4. 8vo.

Horticultural Society, Royal—Proceedings, 1864. No. 12. 8vo.
  Proceedings, 1865. No. 1. 8vo.

Linnean Society—Journal and Proceedings. Nos. 30, 31. 8vo. 1865.

McEroy, John, Esq. (*the Author*)—On the Establishment of a Free Library and an Industrial College in Dublin. (K 91) 8vo. 1864.

Mechanical Engineers' Institution, Birmingham—Proceedings, May, 1864. 8vo.

Meteorological Society, British—Proceedings, No. 15. 8vo 1864.

Moore, Charles H. Esq. M.R.I.—Dr. S. P. Tregelles' Greek Testament. Parts 1 & 2. 4to. 1857-60.

Petermann, A. Esq. (*the Editor*)—Mittheilungen auf der Gesammtgebiete der Geographie. 1864. Nos. 10, 11. Ergänzungsheft, 13. 4to.

Photographic Society—Journal, Nos. 152, 153. 8vo. 1864-5.

Royal Society of London—Proceedings, Nos. 69, 70. 8vo. 1864.

Royal College of Surgeons—Catalogue of Pathological Specimens. Supplement II. 4to. 1864.
  Annual Report of the Conservator. 8vo. 1865.

St. Petersburg Imperial Academy of Sciences—Mémoires: Tome V. Nos. 2-9. Tome VI. 4to. 1862-3.
  Bulletins: Tome V. Nos. 3-8. Tome VI. Tome VII. Nos. 1, 2. 4to. 1861-3.

Scholefield, John, Esq. (*the Author*)—Twenty-four Hours under the Commonwealth. A Drama. 8vo. 1863.

Scottish Society of Arts, Royal—Transactions. Vol. VI. Part 4. 8vo. 1864.
Sedgwick, J. B. Esq. M.R.I.—Mgr Gillis, Panégyrique de Jeanne d'Arc. 3, 4 (L 14) 8vo. Paris. 1857.
The Sanitary Commission of the United States Army. (K 91) 8vo. 1864.
Statistical Society of London—Journal. Vol. XXVII. Part 4 8vo. 1864.
Symons, G. J. Esq. (the Author)—British Rainfall in 1862. (K 91) 8vo. 1864.
United Service Institution—Journal, No. 32. 8vo. 1864.
Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, September und October, 1864. 4to.
Gaskell, Samuel, Esq. M.R.I.—Specimen of Clothes struck by Lightning.

WEEKLY EVENING MEETING,

Friday, February 10, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

W. Gifford Palgrave, Esq.

On Central and Eastern Arabia.

By commerce, by arms, or by knowledge and scientific inquiry, the world seems the destined inheritance of England: and of that inheritance Arabia is not the least extensive or the least interesting portion. In that view I communicate with pleasure a brief summary of the information gained during a journey in the central and eastern regions of the great peninsula—a journey undertaken under the auspices, and forwarded by the liberality, of that constant patron of scientific enterprise, the Emperor of the French.

When the moment came for attempting the exploration of Central Arabia, a task for which seven years' residence in Syria and Egypt had prepared me by a knowledge of the Arabic language, literature, and manners, I assumed the disguise of a native travelling physician, took with me a trusty companion, a Damascene by birth, and in company with a few Bedouins crossed the desert that lies between Gaza and Ma'an. The object of my disguise was not so much personal security as the attainment of greater familiarity in my intercourse with the natives, and consequent facility in observing unobserved. Of course, this same disguise deprived me of many aids common to European travellers—sketch-books, mathematical instruments, and the like; but it procured me, on the other hand, great freedom of action and special means of information.

Having arrived at Ma'an, on the great pilgrim road, at the beginning of June, we made acquaintance with a small band of Bedouins, who offered to conduct us across the waste that lies between that place and the Djowf, the first inhabited land of Central Arabia, which is an isolated oasis lying at the southern extremity of Wadi Serhan, and at an equal distance south-east and south-west from Bagdad and Damascus. It belongs at the present day to the government of Ulal, prince of Shomer. Here we reposed about three weeks, amid a people celebrated for their hospitable and manly character, under the shade of palm groves renowned for their copious fruit, and gardens of vines, apricots, and other fruit trees, rivalling those of Damascus. I ought to notice that the square form given to this oasis in several maps is erroneous, its length from east to west equalling at least ten times its breadth from north to south. By whatever road one desires to reach the midlands of Arabia, one must on some point cross the desert, since it forms a ring round the whole peninsula, behind the mountains which border the sea coast. To the north, where we passed it, this ring is about 180 English miles broad; to the south much more so; on the east and west it is generally narrower, but it exists everywhere.

To trace briefly the line of my journey, it lay—First, from Ma'an to Djowf; next from Djowf across a second arm of desert, luckily a narrower one, to Djebel Shomer, the first mountain range of mid-Arabia, and a kind of advanced bulwark to the central plateau. Once, amid the mountains of Shomer, our way led us by villages and plantations scattered through the deep rocky gorges to the city of Hayel, the capital of the new kingdom of Shomer; whose first limits we had already entered on arriving at Wadi Sushan, when half way from Ma'an to Djowf. Here we remained a month and a half, as doctors to the reigning monarch, Telal Ebn-Rasheed, to the "royal family, and to the town at large." We then crossed the remainder of Djebel Shomer or Aja, for the town of Hayel is in the very heart of the mountain; next passed the broad valley that separates it from the parallel range of Djebel Solma, where Hatim Tai, the most generous, and Antar, the bravest of the Arabs, lie buried, (the Arabs pretended to show us their tombs,) and then traversed the high pasture lands of Upper Kaseem, stopping every evening in some village by the way.

At last, below Kowarah, the last southerly town belonging to the Shomer government, we came to that enormous land-dip where the whole level suddenly sinks down into the vast plain of Southern Kaseem, a region of dates and corn, of traffic and commerce, the most fertile and populous district of Central Arabia. Here begins the Wahhabee empire.

We passed the town of Rass, and a curious stone circle, like that of Stonehenge or Carnac, and after a few villages came to Bereydah, which, by the way, is to the north of Oneyzah, not the south, as most maps erroneously make it. The town is large, and contains about 23,000 inhabitants; here we stopped for some weeks. All was then war in the province; for the Wahhabee armies were besieging Oneyzah, the capital of Kaseem, and we had the pleasure of seeing several reviews and camps, besides one skirmish.

From Bereydah we turned north-east, crossed the rest of Kaseem, and a narrow but difficult sand-pass or nefood that separates between the three provinces of Woshem, Sedeyr, and Kaseem. At last we came to Zulphah, a commercial town on the high road; indeed the only one from Nejed to Barra. It stands in a valley at the foot of Djebel Toweyk.

This mountain here forms a high limestone wall, running from north to south; ultimately it bends like a crescent from east to west, and hence its name Toweyk, or Twist. It is a succession of plateaux, generally in three stages—lower, middle, and higher—the last is the most easterly. Its upper limb forms the province of Sedeyr. Here begins, in Arab parlance, Nejed—*i.e.* the uplands—a term only applied by the natives in Arabia itself to the five provinces situated within the mountains of Toweyk, namely, Sedeyr, Aared, Yemamah, Aflaj, and Woshem.

We now entered the province of Sedeyr. Our first halt was at Ghat; our second at Mejmaà, a large fortified town high up in the mountain. It was, till lately, the capital of the province. We then passed Djelajil and Roudah, and came to Toweym, the actual capital. It is on the second ledge, and consequently higher up than Mejmaà. Then we came to Haft, then to Thoneeyr, and next to a high pass, called Theniyyat Atalah, opposite Djebel Atalah on the east. This is the loftiest point of Djebel Toweyk. It is a little more than three thousand feet above the sea-level. Thence we came to Sadik, next to Horeymelah, a good-sized town well fortified, where Mohammed Ebn Abd-el Wahhab, the founder of the Wahhabee sect, was born. Next we came to Sedous, where ends Sedeyr and begins the province of Aared. At last we entered Wadi Haneefah, the central valley of Arabia, in the midst of Djebel Toweyk; here we passed the ruins of Eyanah and Dereyyuah, the old Wahhabee capital destroyed by Ibraheem Pasha, now deserted, and came to Riad, the modern capital.

Here lives the sultan of Nejed, Feysul, with his eldest son Abd-Allah, and others of the royal family. The town contains at least 25,000 inhabitants. It stands amid beautiful plantations and gardens, whence its name. South of it lie the mountains of Yemamah, famous in Arab poetry, around the heights of Toweyk. Here we passed nearly two months. Then we visited Manfoohah and Selemyah in the Yemamah, a very warm district, where cotton grows in plenty, and thence entered Wadi Soley, the same I suppose with what maps call Wadi Aftan, a name unknown in Arabia itself, to the best of my knowledge. We had now to cross again the high ledge of Toweyk, from whose white steppes we saw far away in the south, on the verge of the Great Desert, the granite hills of Hareek, or "Burning," a very hot province, whose inhabitants are almost as dark as Abyssinians.

Then we descended the eastern side of Toweyk about one thousand feet, and came to the desert, which we now re-crossed to get out of Central Arabia; there are here full eighty miles to pass without water. Next we descended Wadi Farook, a deep valley that separates the Desert of Dahna (*i.e.* red; from the colour of its scorching sands) from the coast range of Hasa mountains, which are basalt and granite; then we descended full a thousand feet more and came on the plain of Hasa between the hills and the Persian Gulf.

In Hofhoof, a town as large as Riad and the capital of Hasa, we remained some weeks—very pleasant ones, for the people are civilized and fond of strangers, and the country is full of running streams, hot-springs, pretty villages, old castles, and fruitful gardens. We then journeyed to Katif, on the shore of the Persian gulf. Here was the residence of the old Carmathian rulers: their palace and castle, built more in a Persian than an Arab style, are still remaining. From Katif we crossed in an Arab ship to Bahreyn, and stopped about a month in the active seaport town of Menamah, and in the neighbouring island of Moharrek, where resides the governor Ebn-Khalifah.

From Bahreyn I crossed over to Katar. This is the first land province belonging to the sultan of Oman, most improperly called the Imam of Mascat; for Mascat is not a capital, nor is he an Imam, nor even a Mahometan, but a Biadi, *i.e.* a Carmathian, or in plain English, a freethinker, like most of his subjects. The capital of Katar is Bedaà, and here I stopped some time with the old governor Ebn-Thani. Here are the best pearl fisheries; the monopoly belongs to Oman, but is farmed at a low price. The land is rocky and barren; behind its low hills lies the Great Desert.

I then crossed, against my will, as a storm took the ship out of her way, to the Arabo-Persian coast, off Barr Faris. Here I visited some towns, such as Chiro and Charak; and then, journeying east by Ras Bustanah, entered the strip of coast which belongs to the sultan of Oman, whose rule extends hence as far as Djask. After a short stay at the thriving port of Linja, I crossed over to Sharja, a good-sized town on the Oman coast, and thence journeyed up by the Djowasmrah Coast to Res Mesandum; visited the once flourishing island of Ormuz, and then came down the coast of the three provinces Ro'os el Djebel, Kalhat, and Batinah to Sohar, one of the three capitals of Oman. The two others are Neywah and Bahhola, in the interior. From Sohar I took ship for Mascat, but the ship went down off the Sowadah islands, and, with a few others, I saved my life by swimming, and regained the coast between Barka and Seeb. Not far hence the sultan of Oman has a country palace, where I paid a visit to his majesty, and then came across country to Mascat. There I remained for some weeks to see the town and the neighbourhood, and then returned by sea up the Persian gulf, and by the Tigris to Bagdad.

Such was the route of my Arab journey. Of course, it was accompanied by occasional danger from Bedouins in the desert, and from the jealousy of the Wahhabees, who readily suspect a stranger to be also a spy in the towns, besides other casualties, such as the shipwreck above mentioned. I will only say that, whoever knows enough Arabic to pass for a native of Damascus or Cairo, and enough medicine or traffic to become doctor or merchant for a year or two, can, with ordinary prudence and patience, visit the whole of Arabia at his leisure, and come off safe, under the protection of Providence.

A few words on the three great kingdoms into which Central and Eastern Arabia is divided. 1. The northernmost is of recent foundation; it embraces the upper part of the peninsula from the desert and the pachalics of Damascus and Bagdad to the north, to the frontiers of Lower Kaseem on the south; Zeima Khaibar and the Djowf belong to it, but its strength and origin lie in the mountains now called Djebel Shomer. It was founded as an offshoot of the Wahhabee empire and under its protection about forty years ago, but has since become entirely independent. The present king, Telal Ebn-Rasheed, is a man of about forty, of extraordinary talents, and real statesmanship. His great aim has been to encourage commerce and agriculture throughout his extensive states, and the great market-place of Hayel is his work. Religion is free throughout his states, and the king has used all his efforts to implant colonies of Shiyaees, Jews, and Christians in the capital itself, and partly succeeded. Within his palace he encourages literary men and poets, who still, as formerly, are the foremost honoured in Arabia. In war he has hitherto been uniformly successful. There is no standing army, but muster-rolls of the militia are kept in the capital, and at a few days' notice I have seen a force of some thousands, well armed and disciplined after Arab fashion, brought together. The provinces are administered by governors, named by the king himself; but each has a counter-check in a local Mejlis, or assembly composed principally of the local nobility.

The climate in this part of Arabia is very temperate, the nights cool, and the air dry. The men of Shomer are the finest specimens of the Arab race; indeed, I have seldom seen anywhere a handsomer people, being courteous, intelligent, and generous, so that a stranger soon finds himself at home among them. In religion, some are Mahometans, a greater number keep up the old Arab practices of prayers to the sun, sacrifices to the dead, sacred groves, &c. However, these are in their way Monotheists, only without the bigotry of Islamitic nations. There is a small Wahhabee party in the capital, but fortunately it is highly unpopular. Morals are better here than elsewhere in Arabia, but gallantry is by no means unknown among the young folks.

The breed of camels is good and abundant. The horses of Shomer are excellent; some are shipped off for India by Koweyt; others go to Bagdad, Damascus, and Egypt, where they pass for Nejdean horses to which, however, they are inferior; for the real Nejdean breed, peculiar to the highlands of Toweyk, is, I have all reason to believe, never exported from its native land—never sold or bartered. When at the Wahhabee capital I was admitted, in quality of veterinary surgeon, to the royal stables, and there saw about two hundred of the very best Nejdees; I never saw, before or after, such perfect beauties. One which I mounted, without saddle or bridle, Arab fashion, was so manageable and pliant, with all his fire, that I could have fancied myself a centaur, and that the horse was part of myself. There are not above four thousand head of this breed in existence.

The total population of the Shomer states amounts to about half a million, or a little more, including townsmen and Bedouins; the military force to about thirty-five thousand. Bedouins are more numerous here than in the rest of Arabia; but they are looked on as far inferior in every respect to the fixed population, and are entirely subject like all others to the Government. On entering the Shomer territories, one gets a passport (price about 1½ thaler) from the first local governor, and then one may travel as secure as in Germany or England.

2. The Wahhabee empire, which has recovered its strength since its overthrow by Ibraheem Pasha, and is still governed by the old family of Ebn-Sa'ood, begins to the south of Shomer. It includes the whole of Central Arabia, from the shores of the Persian Gulf to the frontiers of Mecca; to the south it is bounded by the Great Desert and the Yemen.

It is the most absolute and the most centralized monarchy that I have ever seen, fully as much so as the Roman empire, to which it bears no small resemblance. Its peculiarity lies in the bigotry and fanaticism which form its mainspring of action. The Wahhabees are Koranists to the letter, and whoever is not so, is for them a heretic, polytheist, or infidel. Swearing by any name but that of God, invocation of any creature, Mahomet not excepted, nay even putting the copulative conjunction *waw* between the name of a creature and that of God, and also smoking tobacco, are all crimes which may be punished by death, and not seldom are. Wearing silk or gold ornaments, omitting to pray at the mosque five times a-day, talking or having a light in one's house after night-fall, playing on any musical instrument, and many similar acts are punished with blows at discretion. Adultery, theft, and the like are less severely treated. In consequence, throughout the Wahhabee states, there is much religion, more hypocrisy, and little morality.

The upland country (which is strictly Wahhabee) lies in general from 1500 to 3000 feet above the level of the sea. Here is little desert or sand; the soil is marly, part pasture, part cultivated, especially in the valleys which everywhere intersect the plateau of Toweyk like a labyrinth. The southern slope of the mountain, which forms the provinces of Aared and Yemamah, is the most fertile portion of Nejed; to the east and north it is more barren. The climate is healthy—cool in winter, and not over-hot in summer; but no snow ever falls on Toweyk: rain is however not uncommon, and the winter torrents sometimes sweep away houses and plantations. I only met with one perennial stream; it waters Djeladjil; nor did I hear of any other.

The distinctive character of the people is patience, perseverance, and great concentration of thought and purpose; they are brave and generous, but prone to hatred and bloodshed, often to treachery. Of all Arabs, the Nejdean is the only one who in war postpones plunder to killing; they seldom give or ask quarter. In stature they are generally inferior to the inhabitants of Djebel Shomer, nor equally handsome; but they are strong and enduring of fatigue.

The Nejdean government is a centralized despotism. In all provinces conquered or annexed the native chiefs and nobility are sooner or later put to death, banished, or set aside, and replaced by governors from the capital, often negroes of the palace service. Hence throughout the empire, exists a large party of disaffected, especially in the provinces of Kaseem and Hasa. The Bedouins throughout the empire have been utterly crushed, and the whole monopoly of oppression and robbery is reserved to the Government.

Fanaticism is kept up by countless "Metawwaà's," literally "those who enforce obedience to God," and by the "Meday'yeeyah," or "Zelators" (enthusiasts), a singular institution dating from the Arabian cholera of 1855, and consisting of twenty-two men invested with powers like those of the Roman censors, and whose business is to put down irreligion and immorality, to act as spies, and to bear a large part in government measures. These, with two ministers, one for internal the other for foreign affairs, the chief treasurer (a negro by-the-way), and the Kadi, Abd-el-Latif, a very clever and very dangerous man, great grandson of the first Wahhabee, form the cabinet council of the sultan Feysul, and meet with him officially twice a-week, besides extraordinary consultations. Other public audiences of the sultan are very rare, and private ones yet rarer.

The royal palace in Riad is equal in size to about two-thirds of the Tuileries and strongly fortified with walls, towers, and trench, but of no architectural beauty, and gloomy. The palace of the heir apparent, Abd-Allah, is somewhat smaller, but much handsomer and more regular in its construction. The buildings throughout Nejed and Shomer are with very few exceptions of unbaked brick, which here hardens into a mass almost as strong as stone; the use of the arch is unknown, and hence all large rooms have to be supported on pillars. The great mosque or Djamià at Riad is capable of containing about four thousand persons, but it is perfectly unadorned.

The total population of the Wahhabee empire equals about 1,700,000 souls; its military force is about 60,000. Of its subjects, about half are Wahhabees by principle and politics; the other half because they cannot help themselves, of course; the army is mainly drawn from the former class,

Agriculture, pasture, and war are the main occupations of Nejed. Commerce was so once, but it has much gone down under the Wahhabee system; nor is there hardly any manufacture, unless what is done by shoemakers and blacksmiths.

The coast-province of Hasa is the very reverse of Nejed. A warm, damp climate, hardly any pasture land, running streams and plantations everywhere: the dates of Hasa are the best in Arabia, and conuently in the world: a population fond of commerce, which they arry on as much as their Wahhabee rulers will let them, with Baheyn, Persia, and India; good manufacturers of the finest cloth and mbroidery known in Arabia, and skilful workmen in gold and silver. n religion, most are of the Carmathian or Free-thinking school, though utward conformity to Islam is exacted by the Wahhabee governnent. The whole of the province, its basalt rocks, its hot springs, its ot unfrequent earthquakes, bear witness to volcanic agency.

I have forgotten to say, that in language, the Arabic now spoken mong all classes, high or low, in the towns and villages of Shomer, Kaseem, and Upper Nejed, that is, as far as Riad, is the Arabic of the Koran, without change or corruption, with all the grammatical rules, nflexions, vowel terminations, and observed in common talk no less inutely than in books or mosque sermons. But in Southern Nejed nd Hasa the dialect changes somewhat, and is less exact. The poetry s the same as that of old times in metre, arrangement of rhymes, nd choice of subjects; only in Hasa and Oman this is exchanged for what the people call Nabtee or Nabathæan, where the rhymes are lternate, and the metre is regulated, not by quantity but by accent. met with plenty of manuscripts in the different houses, some treating f religion, others of history, geography, medicine, poetry, grammar, &c., but none of ancient date; nor do any lapidary inscriptions exist hroughout Central Arabia, a great deficiency. Medical science is very ow, mathematics unknown.

3. Time will not permit me to say anything about Bahreyn and the oasts and islands of the Persian Gulf or about Oman, that most ancient nd yet powerful kingdom, whose population, exclusive of its African ossessions, amounts to about 2,300,000, its military force to 90,000, and he annual income of its government to above 1,000,000*l.* sterling (the evenues of Nejed are about one-tenth of that sum). Suffice it to say hat in land and climate—from the lofty heights of Djebel Akhdar, more han six thousand feet above the sea-level, where grow the vine, whose uice the Biadee inhabitants have the good sense to enjoy, the oak, the lane, and other trees and plants of European vegetation, down to the warm plains of Batinah, where the cocoanut, the betel-palm, the mango, apay, sugar-cane, and the like, might make one suppose oneself in India —Oman offers the greatest variety and fertility of any part of Arabia. I hould have wished, too, to say something of its government, based on ocal and municipal institutions, and the nearest approach that I have een in the East to a constitutional form of rules—of its industrious and lever population—of its women, whose unveiled beauty is renowned hroughout Arabia—of its religion, a singular mixture of old Sabæism, ater Persianism, and Carmathian free-thinking—of the hospitable and ocial customs of a land where the stranger sooner than anywhere else inds himself not only a guest but a member of the family—of the ariety which distinguishes its dialect, and recalls the oldest known orms of the Arab language—of its nobles, the Yuaribah, whose ancesral parent, say they, dates from near four thousand years—of its sultan,

the handsome, intelligent, and voluptuous Thoweyni Ebn-Sa'id. But these are matters requiring at least a half-hour to themselves, and as such I pass them by with many other points of Arab nationality and geography, trusting that what has been already said may, in spite of the defects inherent to over-conciseness, suffice to give a general and not incorrect idea of Central and Eastern Arabia.

[W. G. P.]

Friday, February 17th, 1865.

[*No Meeting was held in consequence of the decease of His Grace the* Duke of Northumberland, *the President, on February 12th.*]

WEEKLY EVENING MEETING,

Friday, February 24, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President. in the Chair.

John Evans, F.R.S. F.S.A. &c.

On the Forgery of Antiquities.

Mr. Evans commenced his discourse by observing that there was no maxim of political economy more generally accepted, than that with articles of which the production was unlimited, the supply would always be equal to the demand; while where the supply is limited, an increased demand would always be met by adulterations or imitations of the genuine article, or by something that might be substituted for it. The forgery of antiquities was therefore to be regarded as the inevitable consequence of the high prices paid for them, as it was far easier and more profitable to produce and sell counterfeit antiques than to set to work and dig up or procure in a legitimate manner the genuine articles.

He begged it to be understood that he did not appear in the character of one who was beyond the reach of all imposition, for having more than once been a victim to the forger, he had a fellow feeling for his companions in misfortune.

He explained that though the words counterfeits and forgeries are usually regarded as synonymous, there was, strictly speaking, a slight difference between them: counterfeits, *contra-facta*, being made to imitate genuine originals; forgeries, *fabricata*, though professing to be genuine, not being of necessity imitations, but frequently embodying new conceptions.

Counterfeits and forgeries abound in every department of Archæology—manuscripts, inscriptions, gems, pottery, enamels, glass, ivories, coins, weapons, ornaments, and implements in all metals, and even in stone, have all been fraudulently imitated.

Literary forgeries did not strictly come within the limits of the discourse, though the names of Chatterton and Ireland were familiar to all, and possibly some might have heard of emendations of Shakspeare, and Greek manuscripts, as having been subjects of discussion within the last few years. The forgery of inscriptions dates back to a very early period, having commenced soon after the revival of letters at the close of the fifteenth century. Among others might be cited that "found" at Viterbo, inscribed by Tarquinius to his dearest wife Lucretia, and that said to have been found on the banks of the Rubicon, embodying the decree of the Roman senate against Cæsar's crossing that river. Of late years, owing to the greater means of comparison at command, and the better knowledge of palæography, such forgeries have rarely been attempted, though without reckoning the Book of Mormon, a few cases have occurred in America. Fictitious inscriptions are occasionally scratched upon ancient pottery, and at the present time genuine Roman tiles are exposed for sale in London, with imitations of the impressions of stamps upon them.

Nearly allied to the forgery of inscriptions is that of antique gems, which is carried on to a great extent in Italy. An instance recorded by Mr. King was cited, in which an ancient female bust upon an agate had been converted into a Madonna by the addition of a nimbus, and an entirely modern head of the Saviour had been added upon the other side of the stone. Another instance had been mentioned by Mr. Syer Cuming, of the making of six large scarabæi of amethyst, together with the necklace of the Egyptian king Menes, by an artificer near Drury Lane in 1837. The sepulchral figures of glazed ware, so common in Egyptian interments, are said to be made in this country in large quantities, and exported to Egypt, to be there dug up in the presence of unwary travellers.

Of the frauds in connection with Greek and Etruscan vases, the most venial is that of mere restoration and repainting; but there are other processes by which plain vases of black or red ware are, by scraping or painting, ornamented with figures and inscriptions; but the style of drawing and the unevenness of the surface ought to be sufficient to place purchasers upon their guard. In addition to these metamorphic processes, there have been regular manufactories of fictitious vases both at Vienna and Corfu. These forgeries are usually heavier than the genuine specimens.

Forgeries of Roman lamps and terra-cottas are very common, and not easy of detection in the simpler forms. Many successful counterfeits were produced a few years ago, by an Italian residing in London.

In Mexico, forgery of this kind has been carried on to a great extent, for the Indians still make their unglazed pottery in the same manner as they did before the conquest by Spain; so that when they imitate the real antiques, it is impossible to detect the fraud, though they frequently betray themselves by the details showing traces of European influence.

Imitations of Majolica and Raffaelle ware have been manufactured in abundance, and even the iridescent lustre of the Gubbio ware is counterfeited; nor is this surprising when vases have sold for 200*l.*, and 120*l.* has been given for a single Faenza plate.

Dresden and Sèvres china are counterfeited in the most barefaced manner, and probably more than half of that now exposed for sale in London is fictitious. The false Dresden china has generally a whiter ground than the true, which has usually a tint of blue, and the forged mark is generally painted over the glaze instead of under it. The frauds with regard to Sèvres are often more complicated. In many instances, the whole of the pattern and glaze has been removed from the more common ware, and a fresh ground of turquoise or some of the Royal colours substituted together with fresh medallions or devices. This fraud is difficult of detection, but there is often a mottled look about the surface, and occasionally the forms present anachronisms. Mr. Marryatt records an instance of a déjeûner service offered to Louis XVIII. as having belonged to his grandfather Louis XV., the principal plateau of which was of a form not introduced until 1788, or fifteen years after the death of the reputed owner of the service.

The forgery of Palissy ware has also been conducted on a large scale, and whole collections are frequently palmed off on country collectors as having been formed by some deceased maiden lady, whose representatives are not connoisseurs in china.

Enamels also have been frequently counterfeited, and Mr. Franks has observed that the Manchester Exhibition of 1861 contained specimens imitating nearly all the different varieties of enamel work. In France, the forgery of some Limoges enamels, bought by the Rothschild family, was traced home, and the fabricator punished by a fine of 1000 francs and imprisonment for fifteen months.

Even glass has not escaped, and the beautiful vessels found in the tombs of Thebes have been successfully imitated; and Roman and Greek glass has been counterfeited even to the beautiful iridescence caused by the decomposition of the ancient glass, which is imitated by sticking upon the surface of the modern vessel, scales detached from fragments of really ancient glass.

In ivories, Mr. Franks recognizes two distinct schools of fabrication, one in the S.E. of France, which adopts the Gothic style, the other in the neighbourhood of the Rhine, which prefers to imitate Roman or Romanesque carvings. There has been an instance where several hundred pounds have been paid for one of these productions.

The practice of forging ancient coins was very early adopted, and in he sixteenth century, we find Agostini devoting one of his Dialogues n Medals to this subject, since which time many numismatic writers ave treated of it at greater or less length.

Counterfeit coins may generally be classed under the following eads :—

1. Ancient forgeries.
2. Counterfeits struck from modern dies.
3. Cast coins.
4. Altered coins.

With the first class Mr. Evans was not concerned, for though the oins, as money, were counterfeits, yet, as antiquities, they were genuine. s to the others he entered into some detail, as they illustrated the auds practised with regard to other objects in metal.

The counterfeits struck from modern dies are of two kinds—those hich are forgeries pure and simple, and of which no ancient originals ver existed; and those which are counterfeits in imitation of genuine oins. Of the former were cited as instances, the coins of Priam, with view of Troy on the reverse; of Dido, with the view of Carthage; f Hannibal, with the Latin title of Dux Poenorum; of Julius Cæsar, ith Veni, vidi, vici; and of Augustus, with Festina Lente. Such ieces carry with them their own condemnation. Other imaginary coins ere fairly in accordance with what the genuine coins would probably ave been had such ever existed. Specimens were exhibited purporting be coins of Francis and Mary Queen of Scots, of Henry and Mary, Lady Jane Grey as Queen, and of Richard Cœur de Lion, of whom genuine English coins are known. Of the two coins of Richard I., ne had been struck probably at the close of the last century, the her from dies engraved by Mr. Evans himself, some twenty years go. Neither could for a moment impose on an experienced eye, nor uld they be compared with the works of the renowned Paduan rgers, Victor Gambello, Giovanni del Cavino (known as *the* Paduan), lessandro Bassiano, and others who flourished in the sixteenth century, d whose forgeries, even as such, are held in some estimation. Even envenuto Cellini produced imitations of ancient coins. In later times e most celebrated counterfeiter was the German, Becker, who engraved es for upwards of 300 varieties of coins, principally Greek and oman. Fortunately there are lists published of all his dies, and im- essions from them in lead are preserved in most of the principal useums, so that his works can always be identified. False coins can ten be detected by the forms of the letters and other minutiæ, as well by the appearance of the metal and of the edge. The weight is also metimes a guide. They are occasionally struck upon genuine coins little value, in which case there are sometimes traces left of the ginal impression. An instance was given of a false crown piece Elizabeth, on which, owing to different degrees of oxydization between parts that had been more or less compressed, the names and titles William III. had appeared in a brown tint on the surface.

On silver it is difficult to obtain the peculiar bloom of antiquity, and various chemical means have been resorted to, such as treating with acids, browning with sulphur, or burying the coins in certain compounds. Becker used to place his coins in a box full of iron-filings, attached to the springs of his carriage, and, as he expressed it, "took his old gentlemen a drive," until their surface became dulled by the constant shaking among the filings.

In copper or brass it is easier to give an appearance of antiquity by chemical means, and varnish of different colours has been used to imitate the brilliant coating of brown, chocolate, or various shades of green, communicated to coins by a long sojourn in certain soils, and which is known as the *patina*.

False coins, cast in moulds, are extremely abundant in silver and copper, but occur also in gold. One of this class is engraved as genuine in the 'Monumenta Historica Britannica.' It purports to be an ancient British coin, and the obverse having been moulded from one variety and the reverse from another, a totally new type has resulted from their union. The surface of cast coins usually presents a rather granulated appearance, and there is a want of sharpness in the details, which are in consequence sometimes touched up with the graver. The joint of the mould is also often to be traced.

In altered coins, new types are sometimes produced by the erasure of certain letters, or parts of the device, or even by the substitution by skilful engraving of the head and titles of one emperor for another. In other cases the obverse of one coin is joined to the reverse or obverse of another, so as to produce new and apparently unique varieties. As the joint is carefully concealed in such cases, and as in the others one face of the coin is usually left intact, this is one of the most successful forms of fraud.

Another form of deception, with regard both to coins and antiques, is the assigning of fictitious places of finding to them. Wherever earthworks are going on in London, and these objects are inquired after, there they are sure to be produced; found not on the spot, as asserted, but among the refuse of some curiosity shop in the neighbourhood. Genuine and false coins, Greek and Roman, foreign and English, of all dates, are frequently produced as the result of digging the foundation for a City warehouse!

This system of fictitious finding—one in which the words invention and finding are strictly synonymous—has been of late most successfully practised. It has been exposed by Mr. Franks, Mr. Syer Cuming, Mr. Gunston, Mr. Charles Reed, and others; and moreover, once led to an action for libel, brought by a dealer in antiquities against the 'Athenaeum' newspaper. The dealer had, like many others, been imposed upon, and had purchased a large number of remarkable objects in lead or pewter, that were said to have been found in the formation of a new dock at Shadwell. Many of these were supposed to be Pilgrims' signs, and all were supposed to be connected with some religious proceedings. There were monarchs, knights, archbishops, bishops, and priests; incense-cups, reliquaries, vessels of all forms, and numerous *plaques* and large medallions, with loops for suspension. Their very number and variety afforded some argument against their being regarded as forgeries, as it was urged that no single forger could have such fertility of invention as was exhibited by this series of articles, and that therefore, though exceptional, they were genuine. Unfortunately for such an hypothesis, Mr. Reed had procured some of the plaster moulds in which they were cast, one of which was exhibited. There was also a figure upon a bull, which the forgers had been entrapped into copying from a drawing which was exhibited by its side. The figure of a bishop was also shown, which had been made in the course of twelve hours, in consequence of Mr. Gunston making inquiry after a certain figure, of which he left a sketch in the hands of a workman. The sketch was that of a statue of a bishop, at Rochester, and the name of FABRICATVS was placed on its pedestal in the drawing, and duly re-appeared on the ancient-looking leaden figure.

The manufacture of these objects is still carried on, and numbers are sold both in London and in the country. They usually bear some unintelligible inscription upon them, and frequently a date ranging from 1000 to 1200, and given in Arabic numerals! A considerable number of these forgeries was exhibited, and also some in cock metal, a mixture of copper and lead, which had lately been introduced to imitate bronze, as objects in lead were now held in suspicion. There were daggers, spearheads, celts, tazzas, keys, rings, and medallions, all very carefully cast. Some which are moulded from genuine originals are difficult of detection so long as they retain the coating of river mud with which they have been daubed; but when washed, their modern character is revealed, even to the tooth-marks of the vice in which they have been held to be filed up.

Allusion was next made to the manufacture of forged antiquities in Suffolk, where several ancient British coins, and even the silver seal of the British Prince Cunobeline, had been produced. A silver brooch, bearing the names of four Anglo-Saxon bishops, and a silver chain of the time of the Georges, but bearing the name Cardinal Wolsey upon it, were among the productions of the same artists.

Of other forgeries in metal, armour of all kinds, rings and seals were considered to be the mediæval antiquities most frequently counterfeited; of Roman and Greek, statuettes, bronze vessels of various forms, and various personal ornaments have been favourite subjects.

Mr. Evans next came to modern fabrications in stone, among which also seals claim a place. Specimens were exhibited of counterfeit jet seals and rings. The former are usually founded upon a genuine seal of Osbert de Hilton, preserved in the Whitby Museum, but occasionally claim to be the seals of Roman emperors or English kings. Two of those exhibited, belonging to Mr. Sharp, had been carved in cannel coal, by a notorious forger of flint weapons, one Edward Simpson, or "Flint Jack," and the tool with which they had been executed, an old knife ground to a point, was placed beside them.

The objects in stone, however, that are most frequently counterfeited, are the relics of the so-called Stone Period—of these, numerous specimens were exhibited; among them, two large perforated axes, purchased in Suffolk—one made of soft sandstone, and much better adapted for being cut than for cutting—the other also of sandstone, but disguised with a coating of coloured varnish, to make it resemble some kind of greenstone. Some celts and perforated axes of granite and greenstone were also shown, but neither the forms, nor the character of the surface of the stones, were in accordance with their pretended antiquity. It was mentioned that genuine stone celts with their edges broken are occasionally re-ground, in order to make them more valuable, as being perfect specimens.

It is in flint that forgery has been most rife. Eight or ten years ago there was a manufactory of stone hammer-heads, ancient British urns, and flint weapons of all descriptions on the eastern coast of Yorkshire, principally carried on by one William Smith, *alias* Skin and Grief or Snake Willy. Not only arrowheads and celts of all sizes, but rings, knives, saws, and even fish-hooks of flint were produced, some of which have been engraved as genuine in local Archæological publications. Since then, the manufacture has spread southwards, and many of the forgeries exhibited came out of Suffolk. They have also been produced in Kent, and recently, the most accomplished of the forgers, the Edward Simpson or Flint Jack before mentioned, has made more than one public exhibition of his skill in flint-working in London. The fabrication of stone antiquities is carried on, but on a smaller scale, in the North of Ireland. There is usually a greater difference in the convexity of the two faces of the forged flint arrowheads than in the genuine examples; and in nearly all the forgeries a dullness of surface characteristic of recent fracture.

On the Continent, forgery has been practised in connection with the Lake-dwellings of Switzerland, both with regard to objects in stone and in bone. Even the antiquities found in the cave deposits of France have not entirely escaped. Ancient stone implements have been socketed into ancient bones so as to give them handles, and the result has been modern forgeries composed of genuine antiques. Designs, and even inscriptions, have also been carved on genuine ancient bones, in such a manner as would almost defy detection, but for the character of the drawings and supposed letters. In such cases the best advice to collectors is that given to the public by the Bank of England with regard to their notes—Look not only at the note itself, but also at those from whom you receive it.

Even amongst the most ancient relics of human workmanship with which we are acquainted—the flint implements found in the old gravel deposits of river valleys both in England and France, the forger has been at work; and Icklingham in Suffolk, and Amiens and Abbeville in France, have each produced their own schools of counterfeiters.

Public attention had been called to these forgeries a year and a half ago, by a *cause célèbre*, when the fossil human jaw of Moulin-Quignon was placed on trial before a mixed jury of its own countrymen and of Englishmen, and a verdict returned in which Mr. Evans had been unable to concur. He was not, however, going to re-open that question, and would only observe that while formerly, when the gravel pit of Moulin-Quignon was worked, fossil bones were of excessively rare occurrence in it; now that little or no gravel is dug, human bones have cropped out like mushrooms on its banks, and even a whole human skull has made its appearance.

The forged flint implements from Amiens are usually of the long spear-head type; those from Abbeville are generally flatter, with a cutting edge all round, and ovato-lanceolate in form; those from Icklingham are usually sharply pointed, flat on one face and convex on the other. Of course there are varieties of form, but at all these places they are usually produced for sale enveloped in some clayey matrix, so as to conceal the character of their surface, unless some portion of an ancient surface of flint has been left in chipping them out, in which case the old surface is sometimes wiped clean and the new left covered with mud. It is only after a thorough washing that they appear in their true colours.

The characteristics of age and of novelty were next discussed, but it was observed that though flint implements, which present one or more of the characteristics of antiquity, cannot be of modern manufacture, yet it is by no means so certain that some which retain the characteristics of novelty may not be really ancient. It is known that a fractured flint may preserve its surface unaltered for ages if embedded in chalk, while, if exposed on the surface or embedded in certain soils, a few centuries may serve to change the colour and texture of its surface. In some of the French caves explored by Messrs. Lartet and Christy, certain flint implements come out as fresh-looking as if made yesterday; while others, possibly of a different quality of flint, have their surfaces much altered. Both the character of the flint and the circumstances under which it had lain were to be taken into account in judging of the antiquity of a flint implement; but though certain characteristics may prove that it is not of recent manufacture, it is in the highest degree unsafe to estimate its antiquity merely by the condition of its surface.

There is generally something in the form of the recent forgeries which strikes the practised eye; the method of chipping is different, the angles between the different facets sharper, and the edge also sharper, than is usual with genuine specimens. The surface is commonly dull and lustreless, and if a portion be chipped off, there is no perceptible difference between the recent fracture and the rest of the surface. These remarks were intended to apply more particularly to the common forgeries practised by ordinary workmen.

The principal characteristics of antiquity, more especially of the flint implements from the river gravel deposits, may be summed up under the following heads:—

1. Calcareous incrustations on the surface, caused by the passage of water charged with carbonate of lime over the flints.

2. Dendritic markings, or the small moss-like marks on the surface caused by the peculiar crystallization of a combination of manganese.

3. Marks of wear, caused by the implements having been transported with the other stones forming the gravel along the bed of the ancient river. None of these three characteristics have been imitated by any ordinary forger, though portions of old surfaces with these marks upon them occur on forged implements.

4. Glossiness of surface, sometimes caused by friction, and sometimes probably arising from a partial dissolution of the surface of the flint. There have been attempts made to give this gloss by friction to recent counterfeits; but the lustre is generally such as can be removed by washing.

5. Discoloration of surface. This is one of the best tests of antiquity, as the character of the surface of the flint is completely altered, sometimes to a considerable depth, and instead of retaining its original colour, becomes white, grey, brown, or ochreous, according to different circumstances, often acquiring at the same time considerable lustre. It is only at Abbeville that attempts have been made to colour the surface of counterfeit implements, which was done by smearing them with ochreous clay, or with the beautiful dark pigment of the renowned "black band," according to the position in which they were destined to be found. After washing, however, the Moulin-Quignon specimens show a recently fractured surface, and on some are particles of iron, derived from the hammer with which they had been chipped out, and in a still unoxydized condition, notwithstanding the ages during which they were supposed to have been inhumed.

"But," continued Mr. Evans, "enough has been said of these miserable attempts at fraud. We have taken a glance at nearly every department of antiquity, and in each and all we find that wherever there has been a demand for any particular class of objects, it has more or less been met by a supply of forgeries. I am afraid that what I have said will hardly be regarded as encouraging to collectors, and that it may be thought calculated to throw distrust on all arguments based solely on archæological evidence.

"The case, however, is not so bad as it appears. Great as may be the forger's skill, I do not believe there is one forgery in a thousand that eventually escapes detection. With those long versed in any particular branch of archæology, there is a sort of intuitive perception which enables them almost at a glance to distinguish between the true and the false. And even with those less versed, a little exercise of common sense and careful observation and comparison will suffice to prevent any grievous error. It is surprising, also, how the once having een taken in tends to sharpen the observation; and in this respect it s possible that the existence of forgeries may not be altogether an unmixed evil. Habits of caution and of careful investigation are cheaply urchased, if acquired for a small sum of money invested in worthless orgeries.

"There is, indeed, no reason for the collector or antiquary to lespair; far less reason is there to doubt the value of well-sifted rchæological evidence.

"We do not doubt the existence of genuine coins of Julius Cæsar r of Alexander the Great, because there are numerous counterfeits of hem; much less do we doubt of the former existence of these monarchs. And yet I believe there are some who, because the flint mplements from the ancient fluviatile beds have been counterfeited, ersuade themselves into believing them all to be forgeries: in the ame manner as some others persuade themselves that because there re natural forms of flint which in a measure resemble the implements from the drift, therefore they all are natural and not artificial.

"The existence of these forgeries, however, affords a moderately omplete answer to the latter class of doubters, for the counterfeits of he genuine implements which have imposed upon so many are all *rtificially* chipped out, and have been of necessity then made in order o resemble the originals, which must therefore be regarded as artificial also.

"The other class of doubters will do well to bear in mind that the xistence of a counterfeit generally implies the existence of a genuine original, and that the frauds which have been attempted would never have been discovered, had not those who detected them had sufficient experience of genuine specimens on which to found their judgment. They must also remember, that the exposers of these frauds are precisely those who, having most fully investigated the circumstances, are most fully convinced of the value of those discoveries of relics of primæval man in beds of immense antiquity, of which such interesting accounts have, on former occasions, been given in this room by Mr. Prestwich and Mr. Lubbock.

"It is hard to say which is more mischievous to the advance of science—to believe too little, or to believe too much. For myself, I think that the forgeries we have been examining point the true moral—that enunciated by Epicharmus 2000 years ago—'That the very nerves and sinews of knowledge consist in BELIEVING NOTHING RASHLY.'"

[J. E.]

WEEKLY EVENING MEETING,

Friday, March 3, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President,
in the Chair.

James Fergusson, Esq. F.R.S.

On the Holy Sepulchre and the Temple of Jerusalem.

The object of this discourse was to show that the building in the sacred enclosure at Jerusalem called by Europeans the "mosque of Omar" (but by Mussulmans the "Dome of the Rock"), and supposed by some to have been built by Omar over the site of the altar of the Jewish temple, is really the "church of the Anastasis, or Resurrection," built by Constantine over the rock which he believed to contain the sepulchre of Christ.

The speaker commenced by briefly recapitulating the arguments in his former discourse, on February 21, 1862, on the same subject. On that occasion he had argued the Christian and Constantinian origin of the "Dome of the Rock," mainly from the architecture of that building. No refutation of his arguments having been put forward, and his own recent visit to the spot having destroyed the force of the taunt frequently levelled at him, that he had not been to Jerusalem, while it had confirmed him in his former views, he took this opportunity of re-enforcing them. This he did by the reverse process of argument to that formerly employed—*viz.* by describing the dimensions of the successive temples of the Jews. "If," said the speaker, "I can convince you that the rock which is situated in the centre of the building popularly known as the 'mosque of Omar' is, and always was, known to be outside the temple area, you will be forced to admit that it was not built by the Moslems—the only reason ever advanced for assigning the building of it to them being, that on that rock stood the Holy of Holies, or the altar of the Jews. If it was not built by the Moslems, it was by the Christians; and if by them, it can be no other than the church which Constantine erected over what he believed to be the cave in which the body of our Lord was laid. The architecture is of his age, and neither he nor any other Christian ever built a church in Jerusalem, the whole floor of which was occupied by a great rock with a cave in it, but that which Eusebius describes as the one erected by that emperor."

The heads of the argument in the former discourse were recounted as follows:—

1. The situation of the present so-called church of the Holy Sepulchre in the middle of the town, a locality so much at variance

with the recorded incidents of the passion, that many pious and learned men had denied that it could possibly contain the tomb of the Saviour, notwithstanding the traditions clinging to it, and though unable to suggest any alternative.

2. The fact that the mosque of Omar, so called, was not a mosque, because it had no kibleh; but, on the contrary, its principal entrance was towards Mecca, where the kibleh ought to be; and that though architecturally a tomb in all essential elements, there was no tradition of anyone having been buried in it; and it was so splendid a monument, and of so recent a date, that it was difficult to believe that the tradition had been so completely lost.

3. The solution of the mystery by the discovery that its architecture was of the age of Constantine, which, combined with the form of the building, the rock and the cave, and all the circumstances of the case, led irresistibly to the conclusion that it could be nothing else than the church which Constantine erected over what he believed to be the Holy Sepulchre.

4. The architectural evidence—less appreciable though not less certain than if the building had been Gothic instead of Byzantine of the fourth century.

5. The certainty that the "golden gateway" was a festal portal of the same age as the Dome of the Rock, exactly answering to the gateway leading to the Altar of Constantine's Basilica, as described by Eusebius, while the Mosque El-Aksah was a Saracenic building of the end of the seventh century, more modern in style, that they must be several centuries earlier.

6. The confirmation afforded by the historical argument to the conclusions arrived at from the architectural evidence.

7. The accordance of the locality (if the Dome of the Rock were the Holy Sepulchre) with the Scripture narrative, instead of being irreconcilable therewith as the localities pointed to in Jerusalem were.

The speaker then spoke briefly of his personal experience at Jerusalem. He had noticed no material points of which he had not been previously aware from the plans and drawings of Catherwood, Arundale, the numerous photographs, and the fine engravings of De Vogüé. The extreme beauty of the interior of the building had, however, much surprised him. He was familiar with the Taj Mahal and the other great imperial tombs of Agra and Delhi, and most of the tombs and tomb-like buildings in other countries. But they were all surpassed by the Dome of the Rock, which perfectly realized the instructions of its imperial builder; the elegance of its proportions and the appropriateness of its detail, which does not exist to the same extent in any other building, combined with the mystery of the Great Rock, which occupies the whole floor of the sanctuary, make up a whole, unrivalled in the world. "If the Mohammedans ever did anything as beautiful in any age or any country, the memory of it has passed away. If ever they built anything resembling it, the record of it is gone."

He could not trace in the architecture of the Dome of the Rock a vestige of the style of Justinian's age or of anything that followed it. It seemed worthily to represent the last dying effort of the gorgeous but formal style of Pagan Rome—the first living effort of that freedom and grace which afterwards culminated in the Christian cathedrals of the West.

The speaker then alluded to the cross shown by De Vogüé on the abacus of one of the capitals of the pillars of the building, and to the block or *dossert* which the Christian architects, between the ages of Constantine and Justinian, used, instead of the architrave of the Romans, in their efforts to get rid of the inconvenient entablature, and which they universally adorned with the Christian monogram of the labarum. The crosses, except in the one case, he had failed to find—all had been either chiselled off or plastered over: while the *dosserts* were all cased in marble, and therefore the labarum (if there) was hidden.

As to the Cufic inscription round the interior of the Dome, which states the date of the building as 72 Hejra, or A.D. 691, and the name of the builder as El Mamoun (A.D. 813–833), it is obvious that either the name or date has been altered and falsified, and consequently no argument can be based upon it. But it is remarkable that the rest of the inscription refers to "Jesus the son of Maria," and to Him only, and that His name is mentioned four times over in it. Not one word about David, or Solomon, or Mahomet, the site of the temple, or the altar of the Jews. If it was not known that Christ was buried there, why take such pains to proclaim His mission on the walls?

In proceeding to the immediate object of the present discourse—the description of the dimensions of the temple—Mr. Fergusson commenced with the tabernacle, which was the model for Solomon's temple. He showed that the apparent anomalies in the dimensions given in Exodus, which had hitherto so sorely encumbered restorers of the tabernacle, vanished directly it was assumed that the tabernacle had a "ridge." "It was a tent; and like every tent from before the time of Moses to the present day, it had a ridge. When once this is suggested, the whole becomes clear. Thus, every dimension of the tabernacle is a multiple of 5, except the curtains, which are 14, because they were measured along the slope. There were only four pillars in the interior, but five in the porch, as there must be if there was a ridge. In fact, the moment you assume the ridge, which was indispensable as a protection against the weather, all the difficulties disappear, and every part of the Bible description becomes intelligible.

"When the tabernacle came to be superseded by a more permanent structure, it was copied literally in plan and arrangement, with this marked distinction, that in the edifice of the temple every dimension of the tabernacle was exactly doubled. Thus, the Holy of Holies in the tabernacle was a cube of 10 cubits, in the temple of 20. The Holy place in the tabernacle was a double cube of 10, in the temple of 20 cubits. The porch of the tabernacle was 5 cubits by 10, of the temple 10 by 20. The verandah of the tabernacle was 5 cubits wide, the chambers that surrounded the temple measured 10. But perhaps the most remarkable coincidence is that the angle of the roof made the tabernacle 15 cubits in height, and consequently the temple was raised by a false roof, or upper chamber, till its height was 30 cubits."

The dimensions of the court of Solomon's temple are not given either in the Bible or Josephus; but it may safely be inferred that, like the edifice, they were double those of the tabernacle, and that the court, therefore, measured 100 cubits by 200, or 150 ft. by 300 ft. This is the more probable because the courts of Ezekiel's temple were of that size. In the edifice itself the only difference between Ezekiel's dimensions and those of Solomon arises from the introduction of a range of chambers between the temple court and the north court. The large dimensions of the external boundary of the sanctuary in Ezekiel's account, which have so often puzzled restorers, were dismissed as having no topographical existence; but referring to the division of the land alone, irrespective of the temple, and as representing merely "one of those simple arithmetical ratios to which the Jews were always partial in architectural matters."

The temple of Zerubbabel followed the measurements of Solomon and of Ezekiel, as appears by comparing the notices of Esdras, Josephus, and Hecatæus of Abdera.

So far the pre-Christian temples. The temple of Herod is much more important, because its foundations can still be traced out, and it thus becomes the turning-point of all topographical inquiries at Jerusalem. The authorities for restoring it are Josephus and the book *Middoth* in the Talmud. The house itself was only repaired. It was still standing, as rebuilt by Zerubbabel, when Herod took it in hand, and its dimensions were not altered; the only difference between it and Solomon's being that it retained the passage between the external chambers of Ezekiel, making the width 60 instead of 40 cubits. Two wings were also added to the façade, each 20 cubits square, so that the whole building measured 100 cubits long and 100 cubits wide. It is evident that a building 100 cubits wide could not stand in a court-yard of the same dimensions, and allow a passage round it. We consequently find the breadth of the court increased to 135 cubits, or 202 feet 6 inches, and the length between the porticoes 187 cubits, or 280 feet, leaving 20 feet for the cloisters and the thickness of the walls. The court was strongly fortified, having three gates on the north and three on the south side, and one, the most magnificent of all, towards the east. What had been the outer court, or court of the Gentiles, was cut in two, and appropriated to the women; its breadth was also 135 cubits. Its extent, east and west, can be fixed with very tolerable accuracy by the protraction of the outer court. It must have been, as nearly as possible, 40 cubits, or 60 feet. The important and characteristic addition which Herod made was the great court of the Gentiles, with its "royal porch," 600 feet long and 100 feet wide, suppo by 162 Corinthian columns, which divided it into three aisles, of which the centre one was 100 feet high. The court of the Gentiles surrounded the whole of the other courts, and formed a square, as Josephus expressly states, of which the external measurement was one stadium, or 600 feet, on each side.

Having obtained these general dimensions, the speaker next proceeded to apply them to the existing remains. Here some remarkable coincidences disclosed themselves.

All agree that the south-western angle of the Haram enclosure is one of the angles of the temple area. For 600 feet eastwards from this angle along the south wall all is practically solid. But at that point a range of vaults is reached, unequally spaced, badly constructed, and not only of much more modern age, but too weak to have supported the temple. So far, therefore, did the temple extend; and in this direction the history and the topography are agreed.

Returning to the south-west angle, and measuring 600 feet north, we come to a second bridge or causeway. Up to that point the great "bevilled" masonry of Herod extends; but there it ceases. On this side, again, the history and topography are at one, and thus two sides of the quadrangle are obtained. The other two, lying within the sacred enclosure, have not yet been investigated. The position of the great rock-cut reservoir in front of the Aksah, the watercourses, as far as they have been examined, all accord with the indications of Josephus and the Talmud. Everything tends to show that the temple of Herod was, as Josephus tells us, 600 feet square, and was situated in the south-western angle of the present Haram area.

The rock, therefore, which now stands under the Dome of the Rock, was certainly outside the area of the temple, at a distance of 150 *feet from its northern wall.*

Before leaving this part of the subject, a few words were devoted to showing that the supposition that the altar in the temple was placed upon a rock, is unsupported by any evidence or implication of the Bible, Josephus, or the Talmud; and is, in fact, a mere Mohammedan tradition.

The remainder of the discourse was devoted to an examination of the post-Christian evidence. By citations from the Bourdeaux Pilgrim (A.D. 333), Gregory Nazianzen, Antoninus Martyr (560), and Eutychius (870), Mr. Fergusson urged that the position of the Temple was well known, and the "beautiful gate" standing as late as the end of the sixth century, and that the site of the Temple had been intentionally left waste by the Christians, and turned into a dunghill. In this state of desolation and defilement it was found by the Mohammedans when they conquered Jerusalem, in 636. The Mohammedan accounts are contained in the treatises of Jelal-ed-Deen and Mejr-ed-Deen. They state that Omar obtained from the patriarch of Jerusalem a gift of the site of the temple, on condition that Omar should erect on it *one house of prayer, and no other, in the whole of Jerusalem.* That the one mosque thus erected was the Aksah (built by Abd-el-

Malik in 691), was shown by the testimony of Arculfus (A.D. 700), who mentions the "square house of prayer recently built by the Saracens, and capable of holding 3,000 persons." Arculf's silence as to any Mohammedan building answering to the Dome of the Rock is also difficult to explain on any other supposition than that the Dome of the Rock was a Christian building, and still used as such—in fact, the building which he minutely describes as the Anastasis, or church of the Resurrection. Attention was drawn to the fact that, excluding the building in question, all the early Mohammedan mosques are clustered round the Aksah, and within the limits of the 600 feet already given as the limit of the temple. The speaker further said that Sir Henry Rawlinson had allowed him access to his large and valuable Arabic library, and that he had various works therein contained, examined by a competent Arabic scholar, who had extracted and translated all passages bearing on Jerusalem. The result was, that down to the time of Abd-el-Malik, and later, the limits of the temple were well known to the Mohammedans, and that they neither built, nor pretended to have built, the structure now called the "Mosque of Omar."

"If, then," concluded Mr. Fergusson, "the Dome of the Rock was not built by the Saracens, it must have been built by the Christians; there is no third party to have done it. In that case I would ask, 'What church did Constantine or any other Christian priest or monarch build in Jerusalem over a great rock, with one cave in it, but the church of the Holy Sepulchre?' Till this question is answered—and no attempt has yet been made to reply to it, or to supply its place with any reasonable suggestion—the arguments of my opponents halt.

"As I began, let me conclude. I first took up the question on architectural grounds; I then examined it historically; and, lastly, I investigated it on the topographical ground I have this evening laid before you. Whichever path I attempted to pursue, I always came back to the same point. I do not mean to say that the question is without difficulties, or the road without its ruts and roughnesses; but I do assert that, so far as I can judge, an immense preponderance of evidence, from whatever point it is viewed, is in favour of the conclusion that the building at Jerusalem, known as the Dome of the Rock, is the identical church which Constantine built over what he believed to be the Sepulchre of Christ."

[J. F.]

The discourse was excellently illustrated by diagrams and plans, by a conjectural view of the temple—more intended to show its position with regard to the other parts of the city than to give details of architecture—and by fine coloured drawings of the interior of the Dome of the Rock and the Sacred Rock itself, by Carl Haag and Carl Werner.

GENERAL MONTHLY MEETING,

Monday, March 6, 1865.

WILLIAM POLE, ESQ. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The decease of HIS GRACE THE DUKE OF NORTHUMBERLAND, K.G. F.R.S. the President, on the 12th February last, was announced from the Chair.

Ernest L. S. Benzon, Esq.
John James Unwin Clarke, junior, Esq.
Henry H. S. Croft, Esq.
Woronzow Greig, Esq. F.R.S.
Richard Belgrave Jackson, Esq.
John Macpherson, M.D.
Farquhar Matheson, Esq.
Henry Wilkes Notman, Esq. F.R.G.S.
Charles Rogers, Esq.
James Vaughan, Esq.
Lieut.-Colonel G. F. Whitelocke.

were *elected* Members of the Royal Institution.

F. Woodhouse Braine, Esq.
John Peter Gassiot, Esq. F.R.S.
William H. Harrison, Esq.
H. Bence Jones, M.D. F.R.S.
Thomas Lambert Mears, Esq.
William Miller, Esq.
Charles Robinson, Esq.
James Romanes, Esq.
Edward Y. Western, Esq.

were *admitted* Members of the Royal Institution.

The Chairman announced the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

Henry Bence Jones, M.D. Sec. R. I. (*2nd donation*)	£20	0	0
S. R. Solly, Esq. (*3rd annual donation*)	20	0	0
Adam Murray, Esq.	5	5	0

The PRESENTS received since the last Meeting were laid on the able, and the thanks of the Members returned for the same: viz.—

FROM

siatic Society of Bengal—Journal, No. 296, and Supplementary Number. 8vo. 1864.
stronomical Society, Royal—Monthly Notices, 1864–5. No. 3. 8vo.
ritish Architects, Royal Institute of—Sessional Papers. 1864–5. II. 3. 4to.
hemical Society—Journal for January, 1865. 8vo.
ditors—Artizan for February, 1865. 4to.
Athenæum for February, 1865. 4to.
Chemical News for February, 1865. 4to.
Engineer for February, 1865. fol.
Horological Journal for February, 1865. 8vo.
Journal of Gas-Lighting for February, 1865. 4to.
Mechanics' Magazine for February, 1865. 8vo.
Medical Circular for February, 1865. 8vo.
Pharmaceutical Journal for February, 1865.
Practical Mechanics' Journal for February, 1865. 4to.
Reader for February, 1865. 4to.
araday, Professor, D.C.L. F.R.S. M.R.I.—Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. 1863. 4to. 1864.
ranklin Institute of Philadelphia—Journal, No. 467, 468. 8vo. 1865.
eological Society—Journal, No. 81. 8vo. 1864.
uest, Edwin, Esq. LL.D. F.R.S. M.R.I.—The Invasion of Britain by Julius Cæsar (Archæological Journal, XXI.) 8vo. 1864.
örnes, Dr. M. (the Author)—Die Fossilen Mollusken den Tertiær Beckens von Wien, II. Band. 4to.
orticultural Society, Royal—Proceedings, 1865. No. 2. 8vo.
eeds Philosophical Society—Annual Report. 1863–4. 8vo.
Early History of Leeds. By Thos. Wright, Esq. (L 14) 8vo. 1864.
endy, A. F. Esq. (the Author)—Lendy's Patent Topograph. 8vo. 1865.
innean Society—Journal, No. 32. 8vo. 1865.
eilly, E.—Institutions Scientifiques de la Grande Bretagne. (O 14) 16to. 1865.
eteorological Society, British—Proceedings, No. 16. 8vo. 1865.
etermann, A. Esq. (the Editor)—Mittheilungen auf der Gesammtgebiete der Geographie. 1864. No. 12. Ergänzungsheft, 14. 4to.
hotographic Society—Journal, No. 154. 8vo. 1865.
oyal Society of Edinburgh—Transactions. Vol. XXIII. Part 3. 4to. 1863-4.
Proceedings, No. 62, 63. 8vo. 1863–4.
oyal Society of London—Proceedings, No. 71, 72. 8vo. 1865.
illiman, Professors (the Editors)—American Journal of Science, No. 115. 8vo. 1865.
mith, Mr. J. Russell (the Author)—Bibliotheca Americana: Catalogue of Books, MSS. &c. relating to America. 8vo. 1865.
alford, W. S. Esq. M.R.I.—Three Rolls of Arms, of the 13th Century. Ed. by W. S. Walford and C. S. Percival. 4to. 1864.
right, Charles, Esq.—Reports of the Visitors of the Middlesex Lunatic Asylums at Hanwell and Colney Hatch for 1865. 8vo.
orkshire (West Riding) Geological and Polytechnic Society—Proceedings, 1863–4. 8vo.

WEEKLY EVENING MEETING,

Friday, March 10, 1865.

SIR RODERICK I. MURCHISON, K.C.B. F.R.S. in the Chair.

PROFESSOR A. C. RAMSAY, F.R.S.

On the Eozoon and the Laurentian Rocks of Canada.

MR. RAMSAY commenced by giving a brief account of the physical structure of part of the interior of North America, which consists of great plains and table-lands lying between the ranges of the Laurentian mountains (which run from Labrador far westward along the north shores of the St. Laurence and Ottawa), the mountains of Gaspé and the Appalachian chain, and the gradual slopes of the Rocky mountains in the far west. The Geological Survey of Canada embraces great tracts of the Laurentian mountains and of the mountains of Gaspé, and all the flat country that lies south of the St. Lawrence, the Ottawa, and Lake Huron, and in these territories a vast region has been surveyed in a manner that may fairly be said not to have been surpassed on any part of the North American continent. This survey was begun in the year 1842, and before its commencement the Silurian strata of the United States having been generally correlated to those of Europe, the precise relations of the strata of Canada to both soon began to be established. Before that period very little was known by geologists about the Laurentian rocks, except that they consisted of gneiss, granite, syenite, and so-called igneous masses, and the geological age of the series was undetermined. Indeed, the gneiss of the mountains north of the St. Lawrence, and of the Appalachian chain, of Gaspé, Newfoundland, and other districts were all more or less confounded together, and supposed, *as gneiss*, to be probably of the same or nearly of the same age.

But in 1845 it was first proved by Sir William Logan that the Laurentian gneiss lies *unconformably* under the Potsdam sandstone, a rock well known to be the equivalent of the Lingula flags of Britain, or the "Primordial zone" of Barrande, then and for long after supposed to contain in its lingulæ and trilobites the earliest created forms of organic life. This taken in connection with the discoveries of other American geologists, clearly proved the Laurentian gneiss to be of much earlier date than the greater part of the gneiss of the Green Mountains (a part of the Appalachian chain), and of Gaspé, &c., for they were shown to be the metamorphosed representatives of various members of the Silurian series, most of them younger than the Potsdam sandstone.

This was followed by the discovery of the Huronian rocks, which ere proved also to be older than the Potsdam sandstone, but younger ian the Laurentian gneiss; and not only so, but it was also shown that ie Huronian rocks, themselves metamorphic, were deposited after the ietamorphism of the Laurentian strata; for they contain pebbles and oulders of the latter in such a condition, that it is plain the metamorhism of the masses from which they were derived took place long efore the commencement of the Huronian epoch.

In 1863 a stratigraphical discovery, still more remarkable, was iade; for it was proved that the Laurentian rocks themselves consist f two series of altered strata, the uppermost of which lies in the ighest degree unconformably on the lower series; and it was again ound that the Potsdam sandstone, quite unaltered, lies thoroughly nconformably on the upper Laurentian gneiss.

Besides total unconformity, there is a marked and constant disnction in the nature of the gneiss of the two series, the lower being rthoclase-gneiss, containing potash-felspar, while the upper has been alled Anorthosite-gneiss, containing lime and soda-felspars, much of hich is true Labradorite; and these differences being constant, there no difficulty in distinguishing the two series.

Both series are exceedingly contorted, and have undergone an mount of metamorphism that may almost be called extreme, unless e adopt the view that granite and its allies are the result of an mount of metamorphic action so excessive that the rocks have passed eyond the stage in which foliation still remains.

The Lower Laurentian being at present the oldest known strafied series, its base is unknown; although as it contains in some ses *water-worn stratified pebbles*, it is clear that its original unmetaorphosed materials were derived from the waste of consolidated ratified formations of far older date. Neither are its topmost strata nown, for all the other strata with which it is in contact lie unconrmably upon it. Its known thickness is, notwithstanding, very reat, as the following measured section of a portion of the strata will dicate. It is given in descending order:—

1	Orthoclase gneiss	3,400	feet.
	Crystalline limestone	20	„
	Orthoclase gneiss	1,580	„
2	Crystalline limestone of Grenville, with a thin band of gneiss and *Eozoon Canadense*	750	„
	Orthoclase gneiss, with quartzite and garnets	3,500	„
3	Crystalline limestone, with two bands of gneiss, with garnets and hornblende	2,500	„
	Orthoclase gneiss	4,000	„
4	Crystalline limestone of Trembling lake	1,500	„
	Orthoclase gneiss of Trembling mountain	5,000	„
		22,250	„

It was in 1858 that fossils were found in the band of limestone No. 2; and at first they were considered by Sir Wm. Logan to belong, probably, to the genus of corals known as *Stromatopora*, but renewed examinations, first by Dr. Dawson, Principal of McGill college, Montreal, and afterwards by Dr. Carpenter, establish that in reality the fossils are *Foraminifera*, not detached like those of more modern type, but that they lived and grew in a peculiar mode over wide areas in the sea bottom, in a manner somewhat analogous to the mode of growth of a bank of corals. The chambers (as shown in the diagrams used) are unsymmetrical, and while growing spread irregularly, and they are enclosed above and below by a layer having a finely tubular structure similar to that of the shell of the nummulite and other allied forms. Between these layers the sarcode-body was enclosed, and between the irregular chambers there frequently lies an inter-skeleton, penetrated by numerous branching tubes, and by an occasional larger tube, called by Dr. Carpenter the Stolon. The chambers that contained the sarcode-body and the tubes now consist of serpentine, and the inter-skeleton of carbonate of lime; and on an acid being applied the silicious casts of the tubes are found so arranged that Dr. Dawson and Dr. Carpenter had no doubt as to the organic nature of the specimens, which were examined by them with the microscope most carefully. Better authority it is impossible to have.

Having visited the district with Sir Wm. Logan, I think I may safely say that the chief part of all the bands of limestone is so crystalline (from metamorphic action) that it is hopeless to expect to find fossils in them; but that part of the band No. 2, in which they have heretofore been observed, attains a thickness of about 200 feet, and doubtless Eozoon or other traces of organic remains may yet be found elsewhere. It is by a lucky accident, so to speak, in metamorphic action, that they have been preserved where we now find them, and, said the speaker, "I for one firmly believe not only that all these Laurentian deposits were of marine origin, but also that the original matter of limestones of such vast thickness, and that once spread so widely over that old sea bottom, must have been chiefly formed by the growth and decay of organic bodies."

Mr. Ramsay then showed the importance of these discoveries in relation to *geological time*.

First, he spoke of metamorphism having, according to the best hypothesis, been produced by heated alkaline waters in rocks deeply buried beneath vast accumulations of strata, since removed by denudation.

Before the commencement of the Silurian epoch such metamorphic actions had already taken place three times: first, in the lower Laurentian rocks; secondly, in the upper Laurentian rocks; and thirdly, in the Huronian series, and each set of strata had evidently been subjected to prodigious waste and denudation, before the commencement of the formation that now succeeds it in the American series.

But secondly, geological time is not to be measured merely by the formations now existing, for the unconformities indicate gaps, or periods of time, stratigraphically unrepresented, which were probably far longer in duration than the time occupied in the deposition of the formations that remain.*

Again, an instructive moral may be drawn from a consideration of the subject with regard to the style of reasoning that has often been too prevalent with respect to the discovery of the oldest zones of life of various kinds. For example, for many years no one doubted that the Lower Tertiary or Eocene beds contained the oldest relics of mammalian life, and a great outcry of disbelief was raised when they were discovered in the secondary rocks in the Stonesfield slate of the lower Oolite. Since then the *Microlestes* has been found in the New Red series, and there for the time it rests. The same kind of astonishment prevailed, as reptile bones were successively discovered down through the Lias into the Trias, and from these into the Palæozoic formations of Permian, Carboniferous, and Old Red Sandstone age. And when we consider the history of the mollusca, as recorded by distinguished geologists, the same hankering after finality has constantly cropped out. The "primary formations" it was said contained no fossils, for they were formed before the creation of life began: till late in last century Hutton dispelled the illusion by proving the presence of fossil shells in so-called "primary clay-slates." For some time the Llandeilo flags of Sir Roderick Murchison were regarded as the oldest fossiliferous rocks, till on the discovery of the still older lingula flags and their equivalents in Bohemia, they were fondly named the *primordial zone.* "Here at last is a resting place: we can hope for nothing older than the lingulæ and trilobites of this great original 'primordial zone'; but soon Mr. Salter found annelids, and as he thinks trilobites on a horizon lower still, and the beginning was again thrown farther back into time; and no one dared to dream of traces of life yet older, being found in gneiss, for if they even ever existed there, which is improbable, they must have been all obliterated by metamorphic action. Suddenly Sir W. Logan makes a great leap, thousands of fathoms deeper than any formation previously known to contain the relics of life, and from the limestones there extracts the Eozoon, from rocks so immeasurably older than the oldest Silurian and Cambrian strata, that no power of imagination can feebly realize, even in a geological sense, the great gaps that lie between them: and though we may feebly attempt to estimate the latest lapses of geological time, we can no more hope to fathom these Laurentian depths than we can hope to measure the distance of the most unresolvable of the unresolved nebulæ, merely because we are able to estimate our distance from the sun."

[A. C. R.]

---

* See the Presidential Anniversary Addresses to the Geological Society, for the years 1863 and 1864, by Professor A. C. Ramsay.

WEEKLY EVENING MEETING,

Friday, March 17, 1865.

Major-General Edward Sabine, R.A. Pres. R.S. Vice-President,
in the Chair.

Balfour Stewart, Esq. F.R.S.

On the latest Discoveries concerning the Sun's Surface.

It is well known that a distant body does not impress the eye with the idea of relief.

Thus distant mountains do not *stand out* like the nearer parts of a landscape, and the sun and moon appear only as flat discs.

But although neither to direct nor telescopic vision do these heavenly bodies appear spherical, yet it is possible to produce stereoscopic impressions by combining together two pictures of these bodies taken at different times.

This has been done by Mr. Warren De la Rue with great success, and this gentleman has produced numerous stereoscopic representations of our satellite, in which the general sphericity as well as the unevenness of surface come well out. He has also produced a more limited number of stereoscopic impressions of the sun; but our knowledge of the solar surface is only to a certain extent derived from these impressions, while it is to a greater extent derived from the careful study of ordinary sun pictures.

The bounding luminous surface of the sun is termed his photosphere, and our subject may be divided with reference to the surface into three parts: the first comprising the region above the photosphere; the second, the photosphere itself; and the third, the region beneath the photosphere.

To commence with the region above the photosphere, it may be easily shown that this region contains a very dense atmosphere.

In the first place, according to a well-known law the dark lines in the solar spectrum denote the presence of certain substances in a state of vapour, and yet in a comparatively cold state, above the photosphere of the sun. These substances comprise among others sodium, magnesium, iron, and nickel.

Again, the rim of the sun when viewed by the eye, but more conspicuously in photographs, appears less luminous than the central portions; and this would also appear to indicate the presence of an absorbing atmosphere of lower temperature than the photosphere, so that a ray of light from the border having to pass through a considerable thickness of this atmosphere would become diminished in brightness. (This was illustrated by a beautiful photograph taken by Mr. De la Rue.)

In the third place, the red flames and part of the corona which surround the sun during a total eclipse, reveal to us the presence of an extensive solar atmosphere.

It appeared to the Astronomer Royal and some others as probable that these bodies belong to the sun; but their connection with our luminary was put beyond doubt by Mr. De la Rue, who by means of the Kew heliograph was enabled to take photographic pictures of the sun at the total eclipse which happened in Spain in July, 1860.

(The photographs were exhibited; and it was seen that as the moon proceeded over the sun's disc, the red flames and part of the corona discovered themselves at that side which she had left, and were covered up by her disc at that side towards which she was approaching, thus showing that they belong to the sun.)

Another proof in favour of the idea that the red flames belong to the sun is derived from the nature of the light which they emit. This has great photographic power compared to its luminosity, so much so that one prominence was photographed by Mr. De la Rue, which was invisible to the naked eye. Now such rays can, as far we know, belong only to intensely heated gas, and such gas can only belong to the sun.

Next, with regard to the photosphere, or luminous envelope of the sun, this surface when viewed through powerful telescopes appears granulated or mottled. (Reference was here made to a diagram lent by the Rev. J. Howlett, and to a photograph by Mr. De la Rue.) But besides this, there is reason to believe that great defining as well as magnifying power discloses the fact that the whole photosphere of the sun is made up of detached bodies, interlacing one another and preserving a great amount of regularity, both in form and size. Mr. Jas. Nasmyth was the first to proclaim this curious fact--he called these bodies willow leaves; Mr. Stone has called them rice-grains; Padre Secchi, *coups de pinceau*. (Some photographs from drawings lent by Mr. Nasmyth were then exhibited.)

The faculæ belong to this part of the subject: they are detached portions of the photosphere which are much brighter than the region around them; but this difference in brightness is chiefly apparent near the sun's limb. The reason of this is believed to be, that they are portions of the sun's photosphere thrown up into the higher regions of the atmosphere, by which means they are enabled to escape a great part of the absorbing effect of this atmosphere which is particularly strong near the border; while near the centre the absorption is not great, so that they do not gain much by escaping it.

The idea that faculæ are elevated has been confirmed by a stereoscopic impression of a sun-spot and some faculæ taken by Mr. De la Rue, in which the spot appears to be a hollow while the faculæ appear as elevated ridges.

It should also be remarked, that faculæ retain the same appearance often for a considerable time, sometimes even for days together, so that they are clearly not composed of heavy matter, but are rather of the nature of a cloud.

The phenomena of the third region, or that beneath the photosphere, may be embraced in one word, "sun-spots." These consist of an umbra, or central darkness, surrounded by a less dark penumbra. Mr. Dawes has discovered in some spots even a deeper darkness in the centre of the umbra.

Now if that theory of spots be correct which supposes that they are cavities of which the umbra forms the bottom, while the penumbra constitutes the sloping sides, then the umbra ought apparently to encroach on that side of the penumbra which is nearest the visual centre of the disc.

Prof. Alex. Wilson, of the University of Glasgow, was the first to remark that spots really behaved in this manner, and his observations have been abundantly confirmed by the Kew photographs. (One of these was exhibited.)

It therefore follows, that the umbra of a spot is at a lower level than the penumbra; and since luminous ridges, and sometimes detached portions of luminous matter, cross over spots, it must be concluded that the whole phenomenon is below the surface.

In the next place, spots are the means of exhibiting to us the rotation of our luminary. If we turn to the south and view the sun spots always cross the disc from east to west, that is to say from left to right. (The apparent path of a spot at different seasons was here traced on a diagram, constructed and lent by Rev. F. Howlett; and it was remarked that when allowance is made for the inclination of the earth's axis, the path is really the same at different seasons.)

Besides the apparent motion due to rotation of the sun, spots have also a proper motion of their own, which was discovered by Mr. Carrington. This motion is also from left to right; those near the solar equator moving fastest. Mr. Carrington also remarked that spots confine themselves to the equatorial regions of the sun.

Hofrath Schwabe, of Dessau, has remarked that spots have a period of maximum and minimum nearly every ten years, and General Sabine has found that the year of maximum sun-spots is at the same time that of greatest disturbance of the earth's magnetism.

Finally, the behaviour of sun-spots appears to some extent to be influenced by the planet Venus, in such a manner that when a spot comes round by rotation to the ecliptical neighbourhood of this planet, it has a tendency to dissolve; and on the other hand, as the sun's surface recedes from this planet, it has a tendency to break out into spots.

[B. S.]

WEEKLY EVENING MEETING,

Friday, March 24, 1865.

JOHN PETER GASSIOT, Esq. F.R.S. in the Chair.

PROFESSOR WESTMACOTT, R.A. F.R.S.

On Art-Education, and how Works of Art should be viewed.

THE speaker felt that it would be expected of him to discourse on Art, and especially on that Art to which he had given many years' attention. As, however, it would be impossible to condense, within the short time allowed, any sufficient history of Sculpture, or a clear exposition of the various characteristics of the Art during the long period of its ancient and modern practice, or to enter thoroughly upon merely technical matter, as if he were addressing Art-students, he proposed to take a view of the subject which should interest a general and unprofessional audience; namely, in what way works of Art should be considered by the public, so as to afford the largest amount of gratification and profit.

The interest now taken in Art is a fair ground for offering some remarks on the best way of directing the public intelligence in this important field. Museums, collections, exhibitions, abound all over the country, and the large numbers of visitors to these show beyond dispute how willing people are to find amusement in such displays. The statistics on this subject would be very curious; but, beyond this, they would suggest serious reflection whether this class of entertainment might not be made a means of greatly benefiting the moral and intellectual condition of the people. It is well known that many thousands visit, in the course of every week in the year, the two great public museums of Art in London; while during the ten or twelve weeks only to which the exhibition of the Royal Academy is, of necessity, confined, and when 1*s*. is paid for admission, such large numbers attend that, last season, considerably above £12,000 was taken at the doors.

Now, a question arises, whether, and how far, this general interest felt in Art has had any beneficial influence on the public Taste. The answer scarcely can be considered satisfactory. As a nation, we cannot be said to exhibit this quality in any eminent degree; and the inquiry naturally suggests itself, why, with this large supply of Art and this disposition to look at Art-productions, should this inferiority exist?

Chiefly, then, if not entirely, it may be attributed to the absence of any education in the principles of Art. It is not recognized, even in our universities, as a part of polite training; so that usually, even among the superior classes, the most crude notions prevail upon the theory and principles of design; while all the higher aims and objects of Art are utterly ignored.

The value of any production, whether of High Art or Literature, and the measure of enjoyment to be derived from it, must be in the *ratio* of a person's capacity or power to understand it. How is this power to be acquired?

That there is no indisposition, generally, in the public to be better informed is shown by the readiness with which they seek direction where they fancy it may be obtained. In public galleries an eager interest is shown to listen to any chance explanations that may be going on. On visiting exhibitions of pictures, people seek direction in the same way, or they are found procuring marked catalogues from some one or other whose judgment they may think superior to their own; a proof, at least, of willingness to be assisted, though the advantage gained may sometimes be questioned. They may be told what to look at; but they are not taught *how* to see it. They are without any guide to explain to them the broad principles of Art; in what its value really consists; and what are its claims to consideration as a means of expressing and developing the Beautiful. They simply find particular works pointed out for examination; but no reasons are asked or given for their being thought good, or condemned as bad; and the critic and guide may himself be totally incompetent, if not, as is too often the case, biassed by favouritism or prejudice.

It is precisely here that the want of a sound education in the theory and the principles of Art, as distinct from the merely technical, is seen. The public is thrown upon individual, and perhaps extremely one-sided, opinion, from which it takes its impressions, instead of having the power of forming for itself a judgment based upon a safe foundation.

Amongst the errors to which an uneducated public is prone in estimating works of Art is the fancy that mere imitation constitutes excellence. It has its own very great merit. As a mechanical accomplishment it, no doubt, ranks, and should rank very high: and an artist cannot be too diligent in mastering this most important element of practice, as his language of expression. But it never should be forgotten that imitation is only a means to an end; and not the end, as many seem to think it. It is what words are to the orator:—the language by which ideas are to be conveyed. This erroneous opinion, as to the extreme merit of mere imitation, *per se*, has led to much degradation of Art. Instead of making Art the medium of expressing the great and the good in forms of beauty—as all the great artists of the great periods of Art have done—modern Art is frequently found illustrating the most ordinary and commonplace subjects, selected, as it would seem, simply with the view of enabling the artist to show his skill in the minute and elaborate imitation of what very often are but mean and undignified details. Art should aspire to raise men's thoughts to the beautiful in all things,—in subject as well as in form and treatment—and not to depress and drag them down to the commonplace, and even to what is low and repulsive. Plato made the Good and the Beautiful identical.

Colour, light and shade, perspective, and the ease with which familiar objects may be exhibited in the sister art, offer great temptation to the painter, and much attraction to the general mass of the public; and where the taste is not refined the low quality of a subject will not be felt as any drawback. It is not so in sculpture. Any attempt, here, to indulge in the ordinary and commonplace meets its sure Nemesis. Its fate is certain. While the productions of the great Greek schools, in spite of discoloration, dirt, and mutilation, still justly claim the admiration of all real judges of excellence in this art, there is not a single instance of a work in sculpture of a low or vulgar school that is suffered to have a place in any collection. Yet how are those who are desirous to understand Art to be taught this if no means are afforded for their learning it? Again, then, the want of education in what is true and good in Art is apparent, for here, especially, the better influence of a cultivated taste in the public might have good effect.

It would be a great mistake to suppose that this knowledge may not be imparted. It is not intuitive, but is to be acquired. In Greece the national habits educated the people to a sense of the beautiful. In Italy, in the fifteenth and sixteenth centuries especially, the influence of the higher classes interested the populations in works of Art, and thus their education was practically advanced; and without denying the existence of a more keen sensibility to the beautiful, and more acute observation, in some persons, and even nations, compared with others, it may fairly be assumed that all may in different degrees be improved in their power of appreciating the good wherever it is to be found. Probably all present are acquainted with that charming work on Italy, 'Corinne,' and may remember the chapters in which the works of Art in Rome are described. The value of the knowledge referred to is fully exhibited here. And yet this was the result of education, of its kind. Madame de Stael had been intimate with Schlegel, and she improved her own natural faculties by acquiring from him the power to view Art through an elevated, and, it may be said, a true and proper medium.

In judging a work of Art the first thing to be considered is the intention or purpose of the design, and whether the meaning is clearly expressed. Secondly, it must be tested by the degree of refinement it exhibits; in the choice and character of its subject, and by the mode of presentation adopted by the artist; and here the quality of his taste and mind will be at once seen. Thirdly, the forms should command attention, not only in the human and other figures, but in drapery and all the accessories. Normal beauty should be recognized as essential to all fine Art, and even in the less ambitious subjects there should be a careful avoidance of ugly or repulsive forms. So the Greeks felt, and in this, though we may no longer sympathize with their subjects, their productions still are and ever will be a standard. I radical principle that enabled them, or rather obliged them beauty an element in all their productions. It was seen n their nobler works, but it spread over and down to monest objects: their furniture, vases, *tazze*, earrings, &c. So it was also in the fifteenth and sixteenth centuries, works of the great Italian masters influenced the taste in as is seen in the beautiful performances of Benvenuto Cellini artists of the time; and more modern examples might easily This is one of the *material* consequences of a cultivated ta —and by no means an unimportant one.

The commonplace, and, it must be admitted, pleasing the necessarily refining influence of the Arts, needs scarc noticed here. No doubt the proper office of Art, and of all e human intelligence, should be to refine and elevate; but Ar effect this, of necessity. Experience has shown that, though employed for the noblest objects, it may also be used as an e of corruption, and that the existence of a very refined taste no security for a high moral condition of society. It is in its abuse that its worth is tried. The social state of Ita reigns of Alexander VI., of Julius II., of Leo X., and ot were, according to their own native historians, characteriz prevalence of the most shocking demoralization and profliga very time that Leonardo, M. Angelo, Francesco Francia, and were producing their master-pieces in painting and sculp France in the reigns of Louis XIV. and Louis XV. was able for the general corruption of morals pervading all clas the glory derived from her triumphs in literature and art.

Here, then, is another reason for endeavouring to show how so fascinating an appendage or accessory of civilizatio turned to good instead of to evil. How it may be made an i of moral refinement and instruction, as well as a source of pl

In conclusion, the value of Art-education would be felt in increase of enjoyment people would have in Art. It would t how to observe, and it would quicken their intelligence in appreciating Nature in her true and proper aspect. Its effect seen also on the public Taste. The want of it has, there doubt, a lowering influence both on Art and artists; for where ledge and feeling of the public is wanting in tone, the artis likely to rise above the standard of those from whom the employment. An intelligent public would raise the standard

Another very important benefit might be expected qualifying the public to judge correctly of Art. It would put a stop to the pretentious dictation that prevails in matter where self-elected and incompetent critics make themselve pensers of not only fame but employment. Competition, principle, has lost all its value, from the feeling that exis the comparatively better class of artists that it is a delusion.

none of any position will now submit to be judged by such judges as, ordinarily, compose these competition committees, where, in addition to the possible danger of inadequate qualification in its members, a well-organized party may have arranged beforehand whose design shall have the preference, quite irrespectively of its comparative merit. Nothing would be so calculated to remedy some of the evils here complained of as the improvement of the public intelligence in the requirements and principles of true Art; and in all competitions it might be an advantage to have the advice and assistance of professional, but disinterested men, upon technical questions. The consequences of the absence of such securities for a better class and treatment of public works are sufficiently obvious, without the necessity of more particular reference.

[R. W.]

WEEKLY EVENING MEETING,

Friday, March 31, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President,
in the Chair.

James Glaisher, Esq. F.R.S. &c.

On Scientific Experiments in Balloons.

Mr. Glaisher, at the beginning, referred to the discourse given by him two years since, when he had made eight ascents, for the purpose of scientific researches, in the higher regions of the atmosphere, and said since that time he had made seventeen additional. He described the process of filling a large balloon, and briefly described a balloon ascent, speaking of the novel sensation at first experienced, of the extreme coldness and dryness of the air at great elevations; of the painless death awaiting the aërial traveller who should ascend to an elevation too great for his power of endurance, and compared it to that of the mountain traveller, who, benumbed and insensible to suffering, yields to the lethargy of approaching sleep, and reposes to wake no more. Moral energy in both cases, he stated, was the only means of safety.

He then exhibited the several instruments used, pointing out their extreme sensitiveness and delicacy, and then spoke of the primary objects of balloon research.

Subjects of Research by means of Balloons.

1st. To determine the rate of decrease of temperature, with increase of elevation; and to ascertain whether the results obtained by observations on mountain sides—*viz.* a lowering of temperature of 1° for every increase of elevation of 300 feet—be true or not.

2nd. To determine the distribution of the water, in the invisible shape of vapour, in the air below the clouds, in the clouds, and above them, at different elevations.

3rd. To compare the results, as found by different instruments, together:—

1. The temperature of the Dew Point, as found by—
    - Dry and Wet Thermometers—(Free).
    - Dry and Wet Thermometers—(Aspirated, or air made to pass rapidly).
    - Daniell's Dew Point.
    - Regnault's Dew Point—(Blowing).
    - Regnault's Dew Point—(Air made to pass rapidly).
2. To compare the readings of—
    - Mercurial and Aneroid Barometers, &c.

4th. Solar radiation, by taking readings of the blackened bulb thermometer fully exposed to the sun, with simultaneous observations of the dry bulb thermometer, and also of observations of Herschel's Actinometer.

5th. To determine whether the Solar spectrum, when viewed from the earth, and far above it, exhibited any difference; whether there were a greater or less number of dark lines crossing it, particularly when near sun-setting.

6th. To determine whether the horizontal intensity of the earth's magnetism was less or greater with elevation.

Propagation of sound.
Amount of ozone, &c.

In every ascent a second or third thermometer, differently graduated, has been used to check the accuracy of the readings of the dry thermometer, and the truthfulness of the temperature shown by it. In some of the ascents a delicate blackened bulb thermometer was placed near to the place of the dry-bulb thermometer, fully exposed to the sun in cloudless skies, or to the sky at all times—the readings of this instrument were nearly identical with those of the dry-bulb thermometer in clouded states of the sky, and thus acted as an additional check.

At all times, one or the other, or both, Regnault's and Daniell's hygrometers, have been used sufficiently often at all heights, to show whether the wet-bulb thermometer was in proper action, and to check the results given by the use of the dry- and wet-bulb thermometer on the reduction of the observations.

The author said he would not give a detailed account of the experiments in the year 1862 and 1863, as they were published, but would confine himself to some of the results.

He said it was soon found that the state of the sky exercised a great influence, and the experiments had to be repeated with two groups, one with cloudy skies, and the other with clear skies.

The results are as follow :—

e Decline of the Temperature of the Air, with Elevation, when the Sky was Cloudy.

	Feet		Feet.		Deg.				Feet.
From	0	to	1,000	was	4·5	from	17	experiments, or 1 degree in	223
„	1,000	„	2,000	„	3·6	„	21	„	278
„	2,000	„	3,000	„	3·7	„	22	„	271
„	3,000	„	4,000	„	3·4	„	20	„	295
„	4,000	„	5,000	„	3·3	„	13	„	333
„	5,000		6,000	„	3·2	„	7	„	313
„	6,000	„	7,000	„	2·7	„	5	„	371
„	7,000	„	8,000	„	2·4	„	4	„	417
„	8,000	„	9,000	„	2·2	„	4	„	455
„	9,000	„	10,000	„	2·2	„	4	„	455
„	10,000	„	11,000	„	2·2	„	4	„	455
„	11,000	„	12,000	„	2·2	„	4	„	455
„	12,000	„	13,000	„	2·2	„	4	„	455
„	13,000	„	14,000	„	2·3	„	4	„	435
„	14,000	„	15,000	„	2·0	„	4	„	500
„	15,000	„	16,000	„	2 1	„	4	„	477
„	16,000	„	17,000	„	1·2	„	2	„	833
„	17,000	„	18,000	„	1·3	„	2	„	771
„	18,000	„	19,000	„	1·4	„	2	„	715
„	19,000	„	20,000	„	0·9	„	2	„	909
„	20,000	„	21,000	„	1·1	„	2	„	911
„	21,000	„	22,000	„	0·8	„	2	„	1,250
„	22,000	„	23,000	„	0·8	„	2	„	1,250

These results show, when the sky is cloudy, the decline of tem-ature at every 1,000 feet increase of elevation. Up to 5,000 feet e number of experiments upon which each result is based vary from to 22; at 6,000 and 7,000 feet to 7 and 5 respectively; from ,000 to 16,000 feet to 4; these having been made on two days, *viz.* 63, June 26 and September 29, on which days the balloon was equently enveloped in fog and clouds to the height of three and four iles, and those above 16,000 feet on the former of these two days ly, during the ascent and descent, the sky being still covered with oud when the balloon was between four and 5 miles high.

he Decline of the Temperature of the Air, with Elevation, when the Sky was Clear, or chiefly clear.

	Feet.		Feet.		Deg.				Feet.
From	0	to	1,000	was	6·2	from	9	experiments or 1 degree in	162
„	1,000	„	2,000	„	4·7	„	9	„	213
„	2,000	„	3,000	„	3·8	„	11	„	264
„	3,000	„	4,000	„	3·3	„	12	„	304
„	4,000	„	5,000	„	2·9	„	12	„	345
„	5,000	„	6,000	„	2·6	„	17	„	385
„	6,000		7,000	„	2·5	„	15	„	401
„	7,000	„	8,000	„	2·7	„	12	„	371
„	8,000	„	9,000	„	2·5	„	12	„	400
„	9,000	„	10,000	„	2·4	„	12	„	417
„	10,000	„	11,000	„	2·6	„	13	„	385
„	11,000	„	12,000	„	2·3	„	11	„	435
„	12,000	„	13,000	„	2·2	„	11	„	455
„	13,000	„	14,000	„	2·0	„	11	„	500
„	14,000	„	15,000	„	1·7	„	9	„	[illegible]

	Feet.		Feet.		Deg.				Feet.
From	15,000	to	16,000	was	2·2	from	9	experiments or 1 degree in	455
„	16,000	„	17,000	„	1·9	„	7	„	526
„	17,000	„	18,000	„	1·7	„	7	„	588
„	18,000	„	19,000	„	1·5	„	7	„	666
„	19,000	„	20,000	„	1·3	„	7	„	771
„	20,000	„	21,000	„	1·2	„	7	„	833
„	21,000	„	22,000	„	1·1	„	7	„	911
„	22,000	„	23,000	„	1·0	„	4	„	1,000
„	23,000	„	24,000	„	1·3	„	2	„	771
„	24,000	„	25,000	„	1·1	„	2	„	909
„	25,000	„	26,000	„	1·0	„	1	„	1,000
„	26,000	„	27,000	„	1·0	„	1	„	1,000
„	27,000	„	28,000	„	0·9	„	1	„	1,111
„	28,000	„	29,000	„	0·8	„	1	„	1,250

Up to the height of 22,000 feet, the number of experiments vary from 7 to 17; and there can be but little doubt that the numbers showing the decrease of temperature are very nearly true, and approximate closely to the general law. Above 24,000 feet the number of experiments are too few to speak confidently upon them, but they are in accordance with the series deduced from the experiments at less elevations.

A decline of temperature under a clear sky of 1° takes place within 100 feet of the earth, and at heights exceeding 25,000 feet it is necessary to pass through 1,000 feet of vertical height, as appears in the last column of the preceding table, for a decline of 1° of temperature.

By adding together successively the decline of temperature for each 1,000 feet the whole decrease of temperature from the earth to the different elevations is found; the results, with a cloudy sky, are as follows:—

When the Sky was Cloudy.

	Feet.		Feet.		Deg.		Feet.
From	0	to	1,000	the decrease was	4·5	or 1 deg. on the average of	222
„	0	„	2,000	„	8·1	„	247
„	0	„	3,000	„	11·8	„	255
„	0	„	4,000	„	15·2	„	263
„	0	„	5,000	„	18·5	„	271
„	0	„	6,000	„	21·7	„	277
„	0	„	7,000	„	24·4	„	287
„	0	„	8,000	„	26·8	„	299
„	0	„	9,000	„	29·0	„	311
„	0	„	10,000	„	31·0	„	321
„	0	„	11,000	„	33·0	„	329
„	0	„	12,000	„	35·6	„	337
„	0	„	13,000	„	37·8	„	344
„	0	„	14,000	„	40·1	„	349
„	0	„	15,000	„	42·1	„	356
„	0	„	16,000	„	44·2	„	362
„	0	„	17,000	„	45·4	„	375
„	0	„	18,000	„	46·7	„	386
„	0	„	19,000	„	48·1	„	395
„	0	„	20,000	„	49·0	„	409
„	0	„	21,000	„	50·1	„	419
„	0	„	22,000	„	50·9	„	432
„	0	„	23,000	„	51·7	„	445

These results, showing the whole decrease of temperature of the air from the earth up to 23,000 feet, differ very considerably from those with a clear sky, to be spoken of presently. The number in the last column show the average increment of height for a decline of 1°, as found by using the temperature of the extremities of the column alone. To 1,000 feet high the average is 1° in 223 feet, increasing gradually to 1° in 445 feet at 23,000 feet.

When the Sky was Clear, or chiefly clear.

	Feet.		Feet.		Deg.		Feet.
From	0	to	1,000	the decrease was	6·2	or 1 deg. on the average of	162
,,	0	,,	2,000	,,	10·9	,,	184
,,	0	,,	3,000	,,	14·7	,,	204
,,	0	,,	4,000	,,	18·0	,,	223
,,	0	,,	5,000	,,	20 9	,,	239
,,	0	,,	6,000	,,	23 5	,,	256
,,	0	,,	7,000	,,	26·0	,,	271
,,	0	,,	8,000	,,	28·7	,,	279
,,	0	,,	9,000	,,	31·2	,,	289
,,	0	,,	10,000	,,	33 6	,,	298
,,	0	,,	11,000	,,	35·6	,,	309
,,	0		12,000	,,	37 9	,,	317
,,	0	,,	13,000	,,	40·1	,,	324
,,	0		14,000	,,	42·1	,,	333
,,	0		15,000	,,	43·8	,,	343
,,	0	,,	16,000	,,	46 0	,,	348
,,	0		17,000	,,	47·9	,,	355
,,	0		18,000	,,	49·6	,,	363
,,	0	,,	19,000	,,	51·1	,,	372
,,	0	,,	20,000	,,	52·4	,,	382
,,	0	,,	21,000	,,	53 6	,,	392
,,	0	,,	22,000	,,	54·7	,,	405
,,	0	,,	23,000	,,	55·7	,,	413
,,	0	,,	24,000	,,	57·0	,,	422
,,	0	,,	25,000	,,	58·1	,,	431
,,	0	,,	26,000	,,	59·1	,,	441
,,	0	,,	27,000	,,	60·1	,,	449
,,	0	,,	28,000	,,	61·0	,,	459
,,	0	,,	29,000	,,	61·8	,,	469
,,	0	,,	30,000	,,	62·3	,,	482

These results, showing the whole decrease of temperature from the ground to 30,000 feet, differ greatly, as just mentioned, from those with a cloudy sky.

The numbers in the last column, showing the average increase of height for a decline of 1° of temperature from the ground, to that elevation, are all smaller than those with a cloudy sky at the same elevation. Each result is based upon at least seven experiments, taken at different times of the year, and up to this height considerable confidence may be placed in the results; they show that a change es place in the first 1,000 feet of 1° on an average in 162 feet, incr ng to about 300 at 10,000 feet. In the year 1862, this space of 300 t was at 14,000 feet high, and in 1863 at 12,000 feet. Therefore, change of temperature has been less in 1863 than those in 186 less in 1864 than in 1863, but the experiments have all been taken a different times of the year.

Without exception the fall of 1° has always taken place in th smallest space when near the earth.

Treating the observations for determining the degrees of humidit of the air in the same way, the following are the results :—

When the sky was cloudy, saturation being considered as 100, the degree of humidity on the earth was . . .	74	from	19	experiments.
At 1,000 feet . . .	76	„	33	„
„ 2,000 „ . . .	76	„	34	„
„ 3,000 „ . . .	78	„	35	„
„ 4,000 „ . . .	75	„	27	„
„ 5,000 „ . . .	74	„	16	„
„ 6,000 „ . . .	73	„	14	„
„ 7,000 „ . . .	62	„	11	„
„ 8,000 „ . . .	54	„	11	„
„ 9,000 „ . . .	50	„	11	„
„ 10,000 „ . . .	48	„	10	„
„ 11,000 „ . . .	47	„	10	„
„ 12,000 „ . . .	52	„	6	„
„ 13,000 „ . . .	58	„	6	„
„ 14,000 „ . . .	52	„	5	„
„ 15,000 „ . . .	59	„	3	„
„ 16,000 „ . . .	59	„	2	„
„ 17,000 „ . . .	47	„	2	„
„ 18,000 „ . . .	33	„	2	„
„ 19,000 „ . . .	24	„	2	„
„ 20,000 „ . . .	29	„	2	„
„ 21,000 „ . . .	22	„	2	„
„ 22,000 „ . . .	34	„	1	„
„ 23,000 „ . . .	40	„	1	„

The law of moisture here shown is a slight increase from the ea to the height of 3,000 feet, and then a slight decrease to 6,000 fe the degree of humidity being at this elevation nearly of the same val as on the ground—from 6,000 to 7,000 feet, there is a large decrea and then an almost uniform decrease to 11,000 feet; it increases fr 12,000 to 16,000 feet, and then decreases; the number of experimen up to 11,000 feet, vary from 10 to 33; and I think good confiden may be placed in the result to this elevation, but at heights of 12,0 feet, the number of experiments are evidently too small to speak wi any confidence in respect to the results.

By treating the results with a clear or a nearly clear sky in t same way, the following results were obtained :—

With a clear sky the degree of humidity on the ground was—	59	from	9	experiments.
At 1,000 feet . . .	61	„	14	„
„ 2,000 „ . . .	70	„	17	„
„ 3,000 „ . . .	71	„	23	„
„ 4,000 „ . . .	71	„	19	„
„ 5,000 „ . . .	69	„	17	„

At 6,000 feet	. . .	62	from 15	experiments.
" 7,000 "	. . .	56	" 16	"
" 8,000 "	. . .	50	" 14	"
" 9,000 "	. . .	50	" 9	"
" 10,000 "	. . .	46	" 18	"
" 11,000 "	. . .	43	" 10	"
" 12,000 "	. . .	35	" 8	"
" 13,000 "	. . .	37	" 7	"
" 14,000 "	. . .	37	" 7	"
" 15,000 "	. . .	44	" 5	"
" 16,000 "	. . .	40	" 5	"
" 17,000 "	. . .	39	" 4	"
" 18,000 "	. . .	21	" 2	"
" 19,000 "	. . .	36	" 2	"
" 20,000 "	. . .	33	" 1	"
" 21,000 "	. . .	32	" 1	"
" 22,000 "	. . .	21	" 1	"
" 23,000 "	. . .	16	" 1	"

The law of moisture here shown is a slight increase to 1,000 feet, a considerable increase between 1,000 and 2,000 feet; a nearly constant degree of humidity from 2,000 to 5,000 feet, and a gradual decrease afterwards to 12,000 feet. At greater heights, the numbers are less regular. The results up to 11,000 feet are based upon experiments varying from 10 to 23, and are most likely very nearly true normal values; at heights, exceeding 12,000 feet, the number of experiments have varied from 1 to 8, and no general confidence can be placed in them.

By comparing the results from the two states of the sky, the degree of humidity of the air up to 1,000 feet high, is 15 less with a clear sky than with a cloudy; from 2,000 to 5,000 is from 4 to 6 less; at 6,000 feet the air with a clear sky is much drier than at 5,000 feet, but with a cloudy sky it is nearly of the same degree of humidity, so that the difference between the two states is large, amounting to no less than 11; the difference decreases to 0 at 9,000 feet; but increases to 4 at 11,000 feet; at heights exceeding 11,000 feet, the air with clear skies generally becomes very dry, but with cloudy skies frequently becomes more humid, as was to be expected from the fact of the presence of clouds at heights exceeding three and four miles.

In both states of the sky at extreme elevations, the air becomes very dry, but so far as my experiments go, is never free from water.

The speaker stated that at the end of the year 1863, the results for temperature were laid down on a diagram, and the resulting curve was a hyperbola; continuing this curve upwards, and reading out the decrease of elevation the following were the results, that at the height of

50,000 feet the decline of temperature from the earth would be
100,000 " or 19 mlies " "
200,000 " 38 " "
538,000 " 100 " "
1,056,000 " 200 " "

Showing that large changes take place near the earth, amounting to 24° in the first mile, becoming less and less the farther removed, till the change from 100 miles to 200 miles is less than 3°.

The speaker then said, as these results were deduced chiefly from experiments in the summer and during the hours of the day, it became desirable to take experiments at other times in the year to ascertain whether this law would hold good at all times of the year, and at all times of the day.

For this purpose it was necessary to take experiments in the winter, spring, and autumn. He then described the experiments made at these seasons, and pointed out that experiments made on September 29, January 12, and April 6, during the day, differed very much from the general laws, and those on June 13, 20, and 27, made a little before, at the time of sunset, and a little afterwards, differed materially from those made when the sun was at a good altitude: for instance, on June 13, at the time of sunset, no difference in temperature was experienced for 2,000 feet from the earth.

The speaker then said, it is very clear from the particulars of each ascent, that they cannot all be combined, or all used in deducing general laws. Those ascents which have been made during the past year under similar circumstances to those from which the laws of decrease of temperature were found, when combined do not change the values previously found to any great amount; but those which have been made under other circumstances, such as in the winter, and at times of the setting sun, differ very greatly indeed.

The deviation from this law, however, in winter is certainly of the highest importance to us, the meeting of a strong current of air from the S.W. of so great a depth as nearly one mile, over our country on January 12, in the season of winter, which current I know continued many days, must have exercised great influence. This was the first instance of meeting with a stream of air of higher temperature than on the earth; above this the air was dry, and higher still it was very dry: fine granular snow was falling thickly above this warm stream of air.

The S.W. current being thus observed is of the highest importance as bearing upon the very high mean temperature we experience during winter, so much higher than is due to our position on the earth's surface, and it is highly probable that to its fluctuations the variations of our winters are due.

Our high winter temperature has hitherto been referred for the most part to the influence of the heated water of the Gulf Stream, but if this were the case the same agency being at work around the coast of France, should exercise the same influence, yet we know that the winters of France are more severe than our own, though situated so much south of us.

Dr. Stark, of Edinburgh, some years since referred the mildness of the winters in Britain for the most part to prevalence of the S.W. or anti-trade wind, which is the prevailing aërial current in this latitude during winter.

He observes, so long as these winds blow, we have no frosts or intense colds; but the moment the wind changes during winter to an easterly, north-easterly, or northerly direction, we have both frost and snow, and more or less intense cold.

The S.W. winds in their course meet with no obstruction in coming to us, but they blow directly to us and to Norway over the Atlantic; and hence we enjoy a much milder climate during winter than any other lands not similarly situated with regard to such winds.

The south-west winds cannot reach France till they have crossed the whole of Spain and the high mountain range of the Pyrenees; and by the time they have crossed that mountainous country they are so much cooled that France can derive comparatively little benefit from them, and hence apparently her more severe winters.

Another fact may be inferred from this winter trip; it has always been a matter of great difficulty to me to account for the simultaneous appearance of dense fog over the whole country and extending far out to sea, but the fact of a warm current of air, situated under a mass of snow falling, would fully account for the production of any amount of fog.

Another inference may be drawn from the facts noticed; one only I will mention, and it is this: If during the prevalence of a warm current of air passing over these islands there can be currents of air of so low a temperature as I experienced, it is evident that as it is but a struggle between two or more forces, either of which may preponderate at any moment, it is not safe, therefore, in the winter months, how mild soever the weather may be, to go thinly clothed at any time, for at any moment this warm current may be deflected, and its place occupied by the cold current, and thus some of our sudden and apparently unaccountable changes may be due.

The fact of no change of temperature being met with at the time of sunset on June 13, for 2,000 feet from the earth, that a much smaller change took place than usual on June 20, a little before sunset; and that on June 27, after sunset, as well as could be determined, the change to 3,000 feet was small, it would seem that the *laws which hold good by day do not hold good by night; indeed, it seems probable that at night, for some little distance, the temperature may increase with elevation instead of decreasing.* This can only be determined by experiments at night.

Comparing the results of one experiment with another with respect to the moisture in the air, at the same elevation, it is found to be very different at different times; and that on the same day the moisture is very differently distributed, there having been on some of the days of experiments several successive wet and dry strata placed one above the other.

The variation in this climate, its frequent disturbed atmosphere, the smallness of the country, causing great anxiety after passing through clouds and out of sight of the earth, for fear of descending over the sea, when the balloon has no longer power to keep up, rendering each experiment limited in its du [illegible] t perhaps this country is not the best for determining the laws which govern atmospheric changes.

I am glad to learn that similar observations are contemplated being made in France, and I hope that similar observations will be made in other countries, for it is probable that above the large plains of the continent, where the weather is more uniform, and where an observer can be for hours out of sight of land without anxiety—that the experiments can be more easily made, and probably, too, the general laws made more easily apparent.

Many ascents will, however, be necessary; clouds as large, and clouds far colder than any I have met with, were experienced by Messrs. Bixio and Barral, in their ascents in June and July, 1850, from Paris. These gentlemen made two ascents for scientific purposes, and although from accidents the ascents were of short duration, the results were of high interest. Among them, they noticed that they passed through a cloud of icicles, which sustained themselves in the air, as it appeared to them, contrary to the laws of gravity; but upon their horizontal surfaces they saw beneath them, however, an exact image of the sun, formed by the reflection of the luminous rays on the crystals of ice, floating about in a foggy atmosphere; and they noticed the temperature of the cloud to be as low as minus 40°, a far greater degree of cold than I ever experienced.

With such variations as these, as many ascents will be necessary to be made in France as in England, to determine general laws: but each ascent may be made far richer in results than any one in England. In France, the duration of a journey will be limited only by the wishes of the observer, and not as here by the sea, or by one solitary hour's observations—that being the time frequently in which we approach the sea.

It is certain that there are in the higher regions of the earth's atmosphere spaces subjected to great cold, and others to considerable heat; that there exist some clouds of very low temperature: and some, as those passed through on January 12, for a mile in thickness, of comparatively high temperature.

The presence of such, either cold or hot currents, passing over the country, must play an important part in all our meteorological phenomena, and must exert a great influence upon our climate.

When I first undertook to make these experiments, I expected that a few ascents would have given the information sought; the number of experiments I have now made is twenty-five, and so far from exhausting the subject, they have only indicated a much wider field for future operations.

The law of decrease of temperature under ordinary circumstances, both with a clear and a cloudy sky, when the sun is above the horizon, in the months of summer, I think is pretty well determined: but from the series of observations made in winter, we cannot say such laws hold good throughout the year: neither can we say that the laws which hold good by *ay will be true by night; and the general result of these differences must that the theoretical law of refraction now used, must be abandoned, nd that every observatory will have to determine its own laws, inde-endently.*

Solar Radiation: Blackened Bulb Thermometer, and Herschel's Actinometer Observations.

On August 31, at the heights of 7,000 and 8,000 feet, the black-ned bulb thermometer, exposed to the full influence of the sun, read 3° nly higher than the shaded thermometer.

On September 29, at the height of 14,000 feet, the excess of reading f the blackened bulb thermometer was 2½° only under a bright sun, he increase of readings of the actinometer was from 3 to 5 divisions nly; at 13,000 feet the excess of the blackened bulb readings in-reased to 4° and 5°, and the increase in one minute of the actinometer eading were 7 to 8 divisions. At the height of 3,000 feet and 4,000 eet, the influence of the sun increased, raising the blackened bulb to ° and 8° in excess of the readings of the shaded thermometer, the cale readings of the actinometer increased to 20 and 25 divisions in ne minute, and on reaching the ground the increase in the same time as from 45 to 50 divisions.

On January 12, the readings of the exposed and shaded thermo-eters were nearly alike.

On April 6, I was unable to use the actinometer, and never suc-eeded in placing it properly. The excess of reading of the blackened ulb thermometer was but small during the cloudy state of the sky, nd increased to 5° and 6° at 10,000 feet, this excess increased on de-cending into the lower atmosphere, until cloud was entered.

On June 13, the excess was at all times small.

On June 20, at many inspections the readings of the two thermo-eters were identical.

On June 27, the exposed thermometers nearly always read lower han the shaded thermometer; on examination of these instruments fterwards, they were both found to read correctly.

On August 29, the blackened bulb thermometer read lower than the shaded thermometer till 6,000 feet were passed; it then read higher, increasing to 7° at 14,000 feet high.

From all these experiments it seems that the heat rays in their passage from the sun pass the small bulb of a thermometer, communi-cating very little or no heat to it. Similar results being shown by the use of Herschel's actinometer on every occasion that I have had an opportunity of using it. *From these experiments we may infer that the heat rays from the sun pass through space without loss, and become effective in proportion to the density of the atmosphere or the amount of water present through which they pass, and if so, the proportion of heat received at Mercury, Venus, Jupiter, and Saturn, may be the same as* *that received at the Earth, if the constituents of their atmospheres be the same as that of the Earth, and greater if the density be greater, so that the effective solar heat at Jupiter and Saturn may be greater than at either the inferior planets Mercury or Venus, notwithstanding their far greater distances from the Sun.*

Different Velocities of Air.—The Wind.

On September 29, the balloon left Wolverhampton at 7h. 43m. a.m. and fell near Sleaford, a place ninety-five miles from the place of ascent, at 10h. 30m. a.m. During this time the horizontal movement of air was thirty-three miles, as registered at Wrottesley Observatory.

On October 9, the balloon left the Crystal Palace at 4h. 49m. p.m., and descended at Pirton Grange, a place thirty-five miles from the place of ascent, at 6h. 30m. p.m.; Robinson's anemometer during this time registered eight miles at the Royal Observatory, Greenwich, as the horizontal movement of the air.

On January 12, the balloon left the Royal Arsenal, Woolwich, at 2h. 8m. p.m., and descended at Lakenheath, a place seventyi mles from the place of ascent, at 4h. 10m. p.m.; at the Royal Observatory, by Robinson's anemometer during this time the motion of the air was six miles only.

On April 6, the balloon left the Royal Arsenal, Woolwich, at 4h. 8m. p.m., its correct path is not known, as it entered several different currents of air, the earth being invisible owing to the mist; it descended at Sevenoaks, in Kent, at 5h. 37m. p.m., a point fifteen miles from the place of ascent; five miles was registered during this time by Robinson's anemometer, at the Royal Observatory, Greenwich.

From all the experiments, *the velocity of the air at the earth's surface appears to be very much less than at a high elevation.*

Different Currents in the Atmosphere.—The Wind.

1862.—July 30.

The direction of the wind before starting was N.W.
At 4h. 41m. 15s., at 480 feet, the direction of the wind was S.W.
„ 5h. 17m. 30s. „ 5,165 „ „ N.N.W.
„ 5h. 40m. 30s. „ 6,183 „ „ N.

1862.—September 1.

The direction of the wind before starting was E.N.E. verging to E.
At 5h. 4m. 0s. p.m., at 3,268 feet, the direction of the wind E.N.E.
„ 5h. 10m. 0s. „ „ 3,318 „ „ E.
„ 5h, 11m. 30s. „ „ 3,560 „ „ E.S.E.
„ 5h. 17m. 0s. „ „ 3,580 „ „ E.N.E.
„ 5h. 36m. 0s. „ „ 4,190 „ „ W.

1863.—March 31.

At 4h. 58m. 0s. p.m., at 18,302 feet, the direction of the wind was N,E.
„ 4h. 58m. 30s. „ „ 17,097 „ „ S.W.
„ 5h. 12m. 0s. „ „ 20,865 „ „ nearly W.
„ 6h. 15m. 0s. „ „ 4,441 „ „ S.E.
„ 6h. 16m. 0s. „ „ 5,168 moving back again.

1863.—July 11.

Before starting the wind was E.
At 4h. 59m. 30s., at 2,633 feet, the direction of the wind N.
„ 7h. 14m. 0s. „ 1,876 „ „ E.
„ 7h. 56m. 45s. „ 1,020 „ „ S.E.
„ 7h. 57m. 0s. „ 1,000 „ „ W.

1864.—January 12.

At 2h. 9m. 0s., at 655 feet, direction of the wind was N.E.
„ 2h. 14m. 0s. „ 1,328 „ „ E.
„ 2h. 11m. 0s. „ 1,518 „ „ S.W.
„ 2h. 32m. 0s. „ 5,401 „ „ S.
„ 3h. 3m. 0s. „ 8,086 „ „ S.S.W.
„ 3h. 20m. 0s. „ 10,017 „ „ S.S.E.

Comparison of the Temperature of the Dew Point by different Instruments.

In the experiments of every year, there seems to be no certain ference in the determination of the temperature of the dew point by aniell's and Regnault's hygrometers, and this temperature deter-ined by the use of the dry- and wet-bulb thermometers, seems to be ry closely approximate indeed to the results obtained by either of ese instruments, as will be seen by the following comparison of sults.

As found from all the simultaneous determinations of the tem-rature of the dew point by Daniell's hygrometer, and the dry- and et-bulb thermometers (free).

The temperature of the dew point by the dry- and wet-bulb ree) up

	Feet.		Feet.		Deg.				Experiments.
		to	1,000	was	0·1	lower than by	Daniell's	hygrometer	from 21
From	1,000	„	2,000	„	0·1		„	„	40
„	2,000	„	3,000	„		the same as by	„	„	54
„	3,000	„	4,000	„		„	„	„	60
„	4,000	„	5,000	„	0·4	lower than by		„	33
„	5,000	„	6,000	„	0·6	„	„	„	33
„	6,000	„	7,000	„	0 2	„	„	„	34
„	7,000	„	8,000	„		the same as by	„	„	8
„	8,000	„	9,000	„	1·5	higher than by		„	2
„	9,000	„	10,000	„	1·2	„	„	„	2
„	10.000	„	11,000	„	0·3	„	„	„	1
„	11,000	„	12,000	„	5·6	lower than by		„	3
„	12,000	„	13,000	„	0 3	higher than by		„	5
„	13,000	„	14,000	„	0 8	lower than by		„	7
„	14,000	„	15,000	„	1·0	„	„	„	2

The number of experiments made up to the height of 7,000 feet varying from 21 to 60 in each 1,000 feet as taken in the last three years, are sufficient to enable us to speak with confidence; the results are, that the temperatures of the dew point as found by the use of the dry- and wet-bulb thermometers, and my hygrometrical tables, are worthy of full confidence up to this point. At heights exceeding 7,000 feet, the three years' experiences do not yield a sufficient number of experiments to give satisfactory results. Before we can speak with certainty at these elevations more experiments must be made.

Let us take the balloon as we find it, and apply it to the uses of vertical ascent; let us make it subservient to the purposes of war, an instrument of legitimate strategy; or employ it to ascend to the verge of our lower atmosphere; and as it is, the balloon will claim its place among the most important of human inventions, even if it remain an isolated power, and should never become engrafted as the ruling principle of the mechanism we have yet to seek.

Whether we regard the atmosphere as the great laboratory of changes which contain the germ of future discoveries, as they unfold to the chemist, the meteorologist, the physician; its physical relation to animal life at different heights; the form of death, which at certain elevations is certain to take place; the effect of diminished pressure upon individuals similarly placed; the comparison of mountain ascents with the experiences of aëronauts; these are some of the inquiries which suggest themselves, and faintly indicate researches which naturally ally themselves to the course of balloon experiments.

Sufficiently varied and important they will be seen to rank the balloon as a valuable aid to the uses of philosophy, and rescue it from the impending degradation as a toy, fit only to be exhibited or to administer to the pleasures of the curious.

Already it has done for us that which no other power has accomplished; it has gratified the desire natural to man, to view the earth in a new aspect, and to sustain himself in a new element, hitherto the exclusive privilege of birds and insects. We have been enabled by its aid to ascend among the phenomena of the heavens, and to exchange conjecture for instrumental facts, recorded at twice the elevation the highest mountain permits us to observe.

[J. G.]

GENERAL MONTHLY MEETING,

Monday, April 3, 1865.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

Walter Armstrong, Esq.
Robert Birkbeck, Esq.
Henry Brandreth, Esq. M.A.
James William Butler, Esq.
The Rev. Tullie Cornthwaite, M.A. F.L.S.
George Duppa, Esq.
Mrs. Margaret Henry.
Henry Mather Jackson, Esq.
Major William Lyon.
Sir Theophilus Metcalfe, Bart.
Alexander McDonald, Esq.
Colonel Robert Morrieson.

were *elected* Members of the Royal Institution.

John James Unwin Clarke, jun. Esq.
Richard Belgrave Jackson, Esq.
John Macpherson, Esq.

were *admitted* Members of the Royal Institution.

The Managers reported, That, in pursuance of the Actonian Trust Deed, they had awarded one prize of One hundred guineas to an essay on "The Phenomena of Radiation, as exemplifying the Wisdom and Beneficence of God," by George Warington, F.C.S. The other hundred guineas (not awarded in 1858) were ordered to be reserved to the next award of the Actonian prize, none of the other Essays being, in the judgment of the Committee of Managers, of sufficient merit to entitle the author thereof to such prize.

The **Presents** received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From

Agricultural Society of England, Royal—Journal. Second Series. Vol. I. Part 1. 8vo. 1865.

Astronomical Society, Royal—Monthly Notices, 1864–5. No. 4. 8vo.

Basil Natural History Society—Verhandlungen. IV. 1. 8vo. 1864.

British Architects, Royal Institute of—Sessional Papers. 1864-5. II 4. 4to.

Cator, C. O. F. Esq. M.A. M.R.I. (*the Author*)—Meteorological Diagram for 1864.

Chemical Society—Journal for February, 1865. 8vo.

Editors—Artizan for March, 1865. 4to.

Athenæum for March, 1865. 4to.

Chemical News for March, 1865. 4to.

Engineer for March, 1865. fol.

Horological Journal for March, 1865. 8vo.

Journal of Gas-Lighting for March, 1865. 4to.

Mechanics' Magazine for March, 1865. 8vo.

Medical Circular for March, 1865. 8vo.

Pharmaceutical Journal for March, 1865.

Practical Mechanics' Journal for March, 1865. 4to.

Geographical Society, Royal—Proceedings. Vol. IX. No. 2. 8vo. 1865.

Hawkins, Charles, Esq. F.R.C.S.E. (*the Editor*)—The Works of Sir B. C. Brodie 3 vols. 8vo. 1865.

Horticultural Society, Royal—Proceedings, 1865. No. 3. 8vo.

Linnean Society of London—Transactions. Vol. XXIV. Part 3. 4to. 1864.

Mechanical Engineers' Institution, Birmingham—Proceedings, August, 1864. Part 1. 8vo.

Meteorological Society, British—Proceedings, No. 17. 8vo. 1865.

Moore, Charles H. Esq. M.R.I.—New Entozoötic Malady. By T. S. Cobbold M.D. (K 91) 8vo. 1865.

Petermann, A. Esq. (*the Editor*)—Mittheilungen auf der Gesammtgebiete der Geographie. 1865. No. 1. Ergänzungsheft, 15. 4to.

Expedition to North Pole. (L 14) 8vo

Photographic Society—Journal, No. 155. 8vo. 1865.

Pritchard, The Rev. Charles, F.R.S. (*the Author*)—Eloge of Struve. From Proceedings R. Ast. Soc. 1864.)

Treasurer of St. Bartholomew's Hospital, London—Statistical Tables of the Patients in the Hospital in 1864. 4to.

Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, November und December, 1864. 4to.

Wilkins, W. Noy, Esq. (*the Author*)—Art Impressions of Dresden, Berlin, and Antwerp. 16to. 1860.

Royal Institution of Great Britain.

WEEKLY EVENING MEETING,

Friday, April 7, 1865.

H.R.H. THE PRINCE OF WALES, Vice-Patron, in the Chair.

DR. A. W. HOFMANN, F.R.S.

On the Combining Power of Atoms.

YOUR ROYAL HIGHNESS, LADIES AND GENTLEMEN,

You observe on the lecture-table a great number of bottles, containing an almost perplexing variety of chemical substances; the walls of the theatre are covered with diagrams exhibiting an endless number of formulæ, which some of my audience, I have no doubt, are contemplating with mixed feelings of uneasiness and resignation. Nor will it diminish your discomfort if I tell you that each of the substances on the table represents at least a thousand bodies actually known, and again that each of the known bodies represents a million or more bodies which are not known, but which exist well defined in the mind of the chemist who calls them into life whenever he requires them for purposes theoretical or practical. At the first glance, I admit this is rather a formidable array; but our anxiety is materially lessened, if we learn that this host of substances is formed according to simple laws which it is in our power to discover, and which by the united efforts of chemists are gradually unfolding themselves.

May I be permitted this evening to call your attention to some of the laws, or at all events law-like regularities, recently observed, and which are at present engrossing the interest of the leading chemists of all countries.

I would commence with one of the simplest of experiments:—Here are two gases, hydrogen and chlorine, the one a colourless inodorous gas, which burns quietly with a pale flame, the other a greenish yellow gas, possessing a suffocating odour, and not inflammable. When equal volumes of these two gases are mixed together, and a light applied to

British Architects, Royal Institute of—Sessional Papers. 1864-5. II. 4. 4to.

Cator, C. O. F. Esq. M.A. M.R.I. (*the Author*)—Meteorological Diagram for 1864.

Chemical Society—Journal for February, 1865. 8vo.

Editors—Artizan for March, 1865. 4to.
Athenæum for March, 1865. 4to.
Chemical News for March, 1865. 4to.
Engineer for March, 1865. fol.
Horological Journal for March, 1865. 8vo.
Journal of Gas-Lighting for March, 1865. 4to.
Mechanics' Magazine for March, 1865. 8vo.
Medical Circular for March, 1865. 8vo.
Pharmaceutical Journal for March, 1865.
Practical Mechanics' Journal for March, 1865. 4to.

Geographical Society, Royal—Proceedings. Vol. IX. No. 2. 8vo. 1865.

Hawkins, Charles, Esq. F.R.C.S.E. (*the Editor*)—The Works of Sir B. C. Brodie. 3 vols. 8vo. 1865.

Horticultural Society, Royal—Proceedings, 1865. No. 3. 8vo.

Linnean Society of London—Transactions. Vol. XXIV. Part 3. 4to. 1864.

Mechanical Engineers' Institution, Birmingham—Proceedings, August, 1864. Part 1. 8vo.

Meteorological Society, British—Proceedings, No. 17. 8vo. 1865.

Moore, Charles H. Esq. M.R.I.—New Entozoötic Malady. By T. S. Cobbold, M.D. (K 91) 8vo. 1865.

Petermann, A. Esq. (*the Editor*)—Mittheilungen auf der Gesammtgebiete der Geographie. 1865. No. 1. Ergänzungsheft, 15. 4to.
Expedition to North Pole. (L 14) 8vo.

Photographic Society—Journal, No. 155. 8vo. 1865.

Pritchard, The Rev. Charles, F.R.S. (*the Author*)—Eloge of Struve. (From Proceedings R. Ast. Soc. 1864.)

Treasurer of St. Bartholomew's Hospital, London—Statistical Tables of the Patients in the Hospital in 1864. 4to.

Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, November und December, 1864. 4to.

Wilkins, W. Noy, Esq. (*the Author*)—Art Impressions of Dresden, Berlin, and Antwerp. 16to. 1860.

Royal Institution of Great Britain.

WEEKLY EVENING MEETING,

Friday, April 7, 1865.

H.R.H. The Prince of Wales, Vice-Patron, in the Chair.

Dr. A. W. Hofmann, F.R.S.

On the Combining Power of Atoms.

Royal Highness, Ladies and Gentlemen,

You observe on the lecture-table a great number of bottles, ining an almost perplexing variety of chemical substances; the of the theatre are covered with diagrams exhibiting an endless er of formulæ, which some of my audience, I have no doubt, are plating with mixed feelings of uneasiness and resignation. Nor diminish your discomfort if I tell you that each of the substances table represents at least a thousand bodies actually known, and that each of the known bodies represents a million or more bodies are not known, but which exist well defined in the mind of the ist who calls them into life whenever he requires them for pur- theoretical or practical. At the first glance, I admit this is a formidable array; but our anxiety is materially lessened, if n that this host of substances is formed according to simple which it is in our power to discover, and which by the united s of chemists are gradually unfolding themselves.

y I be permitted this evening to call your attention to some of s, or at all events law-like regularities, recently observed, and are at present engrossing the interest of the leading chemists of ations.

I would commence with one of the simplest of experiments:—Here o gases, hydrogen and chlorine, the one a colourless inodorous which burns quietly with a pale flame, the other a greenish yellow sing a suffocating odour, and not inflammable. When equal s of these two gases are mixed together, and a light applied to the mixture, an explosion takes place, a compound gas being produced which fumes in the air, and which, when dissolved in water, constitutes the spirit of salt, or muriatic acid of the earlier chemists, now called *hydrochloric acid*.

By certain processes, which we must not inquire into at the present time, the compound of hydrogen and chlorine, called hydrochloric acid, may be made to unite with another gas, oxygen; the combination giving rise to the formation of an acid called *hypochlorous acid*, and by which most of the bleaching operations carried out in commerce are effected. On plunging an appropriately-prepared piece of Turkey-red calico into a warm solution of chloride of lime, which is closely related to hypochlorous acid, you observe that a white pattern is produced on the cloth.

Again, an additional quantity of oxygen may be united to hypochlorous acid, when the compound called *chlorous acid* is formed. A well-known salt of commerce, chlorate of potassium, is generally used for its preparation. This salt is readily decomposed by acids. The explosive violence with which sulphuric acid acts upon it, the detonation attended by flashes of light, are phenomena early and frequently observed by the laboratory student. By substituting nitric for sulphuric acid, an explosive gas is formed, which, when dissolved in water, constitutes the chlorous acid in question.

A third compound, *chloric acid*, may be formed by the addition of a further dose of oxygen to chlorous acid. The most familiar salt of this acid is the chlorate of potassium just mentioned. This, as well as other derivatives of chloric acid, is largely used for pyrotechnic purposes. Here we must be satisfied with calling attention to a species of white gunpowder which has been lately devised, and which consists of a mixture of the potassium salt with tannic or gallic acid.

Lastly, by still further increasing the supply of oxygen, a fourth compound, *perchloric acid*, is produced. This substance again exhibits the explosive habitudes of the group of bodies in question. When made to combine with aniline, for instance, perchloric acid gives rise to a compound which goes off when heated in a test-tube, burning, as you observe, with an intense white light.

A glance at the diagram shows us the regularity with which the amount of oxygen increases in this series of oxygenetted derivatives of hydrochloric acid. There is nothing arbitrary in this accession; each increment ensues step by step.

Increment of Oxygen.

Hydrochloric acid . .	HCl
Hypochlorous acid . .	$HCl + O = HClO$
Chlorous Acid . . .	$HCl + 2O = HClO_2$
Chloric Acid	$HCl + 3O = HClO_3$
Perchloric Acid . . .	$HCl + 4O = HClO_4$

Looking at the simplest body at the head of the list, we find it to e a compound of one atom of hydrogen with one atom of chlorine. 3y uniting this compound with one atom of oxygen, we obtain ypochlorous acid; by adding another, we produce chlorous acid; he accession of a third atom gives rise to chloric acid; and a fourth tom of oxygen, lastly, produces perchloric acid.

The same gradual rise in the successive additions of oxygen may e traced in numerous other groups of bodies. For the present we rill confine our attention to two more series.

Under the name of *olefiant gas*, a transparent colourless gas, urning, as you observe, with a brilliantly luminous flame, is known, rhich consists of carbon and hydrogen. By a circuitous process, rhich must not detain us, this gas may be converted into a peculiar, ery volatile liquid of a pungent odour, which chemists have called *ldehyde*. This substance, which is more readily procured by sub-itting alcohol to the action of oxidizing agents, may be looked pon as a compound of olefiant gas with oxygen. Aldehyde is marked y its powerful attraction for oxygen; so greedily, indeed, does it absorb is gas, that it is almost impossible to preserve aldehyde except hermetically-closed vessels. Nor does aldehyde unite only with xygen when it meets with it in the free state; combined oxygen is qually attracted by it. When gently heated with oxide of silver, dis-lved in a suitable liquid, aldehyde very rapidly removes the oxygen om the oxide, metallic silver in a lustrous condition being deposited n the surface of the vessel in which the operation is performed. This action, first observed by Baron Liebig many years ago, has recently een modified so as to admit of industrial application on a large scale r the manufacture of looking-glasses and reflectors for astronomical strumenta. When aldehyde is thus oxidized, it is converted into a ompound called *acetic acid*, well known to everyone as the principal nstituent of common vinegar.

Again, acetic acid may be made to unite with an additional quantity f oxygen to produce a compound called *glycolic acid*, an acid which s been discovered during the last few years, but which has not at resent received any useful applications.

On referring to the following diagram we perceive the simple lation existing between these four bodies:—

Increment of Oxygen.

Olefiant gas . . .	$C_2 H_4$
Aldehyde	$C_2 H_4 + O = C_2 H_4 O$
Acetic acid	$C_2 H_4 + 2 O = C_2 H_4 O_2$
Glycolic acid . . .	$C_2 H_4 + 3 O = C_2 H_4 O_3$

We observe here exactly as in the previous series the gradual assimilation of oxygen. Olefiant gas by absorbing one atom of oxygen produces aldehyde; by absorbing a second atom it gives rise to the formation of acetic acid; by a third annexation of a similar quantity of oxygen, lastly, glycolic acid is formed.

May I be permitted to quote an additional instance. In the oil obtained from the seeds of the *croton tiglium* chemists have discovered a peculiar acid, *crotonic acid*, which has been lately observed also among the derivatives of mustard.

This substance, consisting of carbon, hydrogen, and oxygen, is convertible by oxidation into another acid, *succinic acid*, a beautiful crystalline body, which is more frequently obtained by submitting the familiar resin amber to the action of oxidizing agents.

Succinic acid, when combined with an additional atom of oxygen, gives rise to the formation of *malic acid*, a crystalline acid largely present in the juice of apples and rhubarb, the substance indeed to which the acid reaction of these juices is chiefly due. On cutting an apple or a piece of rhubarb, and pressing the cut surface against a piece of blue litmus paper, it is immediately reddened.

But malic acid also may be still further oxidized, the product being one of the most familiar vegetal acids, *tartaric acid*. This acid is one of the compounds existing largely in the juice of grapes. When a grape is squeezed on a piece of blue litmus paper, the latter is reddened wherever it comes in contact with the grape juice.

The molecules of all these acids contain the same number of carbon atoms and also the same number of hydrogen atoms, the difference in their composition consisting entirely in the number of oxygen atoms which are present, as obvious by reference to the diagram.

Increment of Oxygen.

Crotonic acid . . $C_4 H_6 O_2$
Unknown . . . $C_4 H_6 O_2 + O = C_4 H_6 O_3$
Succinic acid . . $C_4 H_6 O_2 + 2 O = C_4 H_6 O_4$
Malic acid . . . $C_4 H_6 O_2 + 3 O = C_4 H_6 O_5$
Tartaric acid . . $C_4 H_6 O_2 + 4 O = C_4 H_6 O_6$

In this diagram an unknown acid $C_4 H_6 O_3$ figures between crotonic and succinic acids. This substance has not yet been obtained, but the experience of the gradual assimilation of oxygen in other series permits us to forecast the existence of this compound. Though not yet actually prepared, I have not hesitated to introduce it into the list of bodies derived from crotonic acid by simple oxidation.

The three examples which we have studied unmistakably show us that oxygen is capable of combining with other groups of elements so as to give rise to new compounds: that this combination takes place stepwise, atom by atom: that the fundamental properties of the original compound remain more or less unaltered in the new compound of greater complexity, and that the amount of oxygen thus, so to say, assimilated, is in no way dependent on the greater or less complexity of composition of the original compound. In the first case we had the simplest of all possible compounds, hydrochloric acid consisting of one atom of hydrogen and one of chlorine; in the second case we started with a compound containing two atoms of carbon and four of hydrogen, altogether six atoms, while in the case of crotonic acid not less than four atoms of carbon, six of hydrogen, and two of oxygen, altogether twelve atoms, were involved.

An endless variety of similar examples might be quoted for the purpose of illustrating the generality of the inferences we have drawn, but I will, with your permission, assume that I have established my point.

We have in the next place to examine whether substances are capable of combining with nitrogen, exactly as we have just seen them unite with oxygen. Remembering as we do that nitrogen is rather marked by the absence of salient combining powers, we are not surprised to learn that all attempts hitherto made with the view of adding nitrogen directly to other bodies have entirely failed. But even indirectly by availing ourselves of roundabout ways, by calling to our aid the multitude of reactions which modern chemistry has brought to light, nitrogen cannot be *added* to other substances without introducing at the same time other elements into the composition of the compound. Let us endeavour to illustrate this point by examples: we could not perhaps quote a better case than that of *benzol*, the substance which is the starting point of the manufacture of aniline, the source of the beautiful colours so much in request at the present time. Benzol consists of carbon and hydrogen. No one has, as yet, succeeded in uniting this substance with nitrogen alone. Nothing on the other hand is easier than to combine benzol simultaneously with nitrogen and hydrogen. The very transition of benzol into *aniline* involves the assimilation by the benzol molecule of one atom of nitrogen and one atom of hydrogen. Again, aniline is capable of fixing a second atom of nitrogen, but not without assimilating also a second atom of hydrogen. The compound thus produced is a beautiful crystalline body called *phenylene-diamine*, which is likely to receive some interesting applications in the manufacture of brown dyes. To this compound again additional atoms of nitrogen and hydrogen may be joined, a fourth substance, as yet without application, *picryl-triamine*, being formed. The following diagram, in which again the simplest compound (benzol) is placed at the top of the list, shows how these several substances are related to each other.

Increment of Nitrogen.

Benzol . . . . C_6H_6
Aniline . . . . $C_6H_6 + HN = C_6H_7N$
Phenylene-diamine. $C_6H_6 + 2HN = C_6H_8N_2$
Picryl-triamine . . $C_6H_6 + 3HN = C_6H_9N_3$

Let me give you another and even simpler series in illustration of the same point. Hydride of ethyl, like benzol, refuses to combine with nitrogen, but it also receives into its molecule one atom of nitrogen and one atom of hydrogen, the well-known substance *ethylamine*, which has the greatest analogy with ammonia, being formed. This, by a repetition of the same transaction, is converted into *ethylene-diamine*, an oily base of great causticity; while a third repetition of the process produces a compound, *vinyl-triamine*, the existence of which is not yet fully established. The analogy between the first and the second series is obvious by a comparison of the formulæ.

Increment of Nitrogen.

Hydride of ethyl . C_2H_6
Ethylamine . . . $C_2H_6 + HN = C_2H_7N$
Ethylene-diamine . $C_2H_6 + 2HN = C_2H_8N_2$
Vinyltriamine . . $C_2H_6 + 3HN = C_2H_9N_3$

We entirely refrain from examining into the particular processes, varying to a very considerable extent, by which these transformations are accomplished, the only point, which we have an interest in establishing here, being that nitrogen, when it joins a compound, joins not alone, but in company with hydrogen. In this respect then nitrogen essentially differs from oxygen, which we saw combining with bodies, atom by atom, without involving the introduction of other materials.

Can we explain this strange difference in the behaviour of oxygen and nitrogen? Before endeavouring to answer this question, let us examine in what manner carbon atoms are received into the molecules of bodies, whether like oxygen atoms they are capable of joining directly, or like nitrogen atoms they are accepted only when presenting themselves in company with other atoms. Investigation of a special case appears best fitted to supply the desired information.

Among the endless number of carbon compounds, we could not possibly select a simpler one than *marsh-gas*. This transparent colourless inflammable gas, as everyone knows, escapes from the fissures of the great coal measures and accumulates in the gal-es of ill-ventilated coal mines, frequently giving rise to the losions so much dreaded and deplored. It is also often deve- ed from stagnant pools and swamps, in general from marshy lands, ence its name. Marsh-gas consists of carbon and hydrogen. Is substance convertible into a compound which contains a larger ount of carbon? By a series of processes far too numerous and nplicated to admit of being discussed this evening, marsh-gas may converted into *hydride of ethyl,* a substance of very similar perties, and which the members of the Royal Institution have quently seen prepared by a simpler method discovered by Dr. nkland, *viz.:* the action of zinc-ethyl upon water. Hydride of yl contains one atom of carbon more than marsh-gas, but with this bon atom, two hydrogen atoms have been simultaneously conferred n the marsh-gas molecule. On submitting hydride of ethyl to a ilar series of transformations we convert it by the addition of ther carbon atom into *hydride of propyl,* but not without fixing in two atoms of hydrogen.

The same processes may be repeated again and again, hydride of pyl being converted in its turn into *hydride of butyl,* and hydride outyl into *hydride of amyl.* We arrive in this manner at a series odies very similar in their properties, each of them differing from previous one by the accession of one carbon atom invariably linked h two atoms of hydrogen. Many members of this series are found ongst the products of the distillation of coal; others, especially those ier in carbon, existing in the American oils, which are now being so ch used for lighting and other purposes.

The composition of these several bodies may be exhibited in the owing diagram:—

Increment of Carbon.

HYDRO-CARBONS.

Marsh-gas	CH_4
Hydride of ethyl . . .	$CH_4 + CH_2 = C_2H_6$
Hydride of propyl . .	$CH_4 + 2\ CH_2 = C_3H_8$
Hydride of butyl . . .	$CH_4 + 3\ CH_2 = C_4H_{10}$
Hydride of amyl . . .	$CH_4 + 4\ CH_2 = C_5H_{12}$
Hydride of caproyl . .	$CH_4 + 5\ CH_2 = C_6H_{14}$
Hydride of œnanthyl .	$CH_4 + 6\ CH_2 = C_7H_{16}$
Hydride of capryl . .	$CH_4 + 7\ CH_2 = C_8H_{18}$

But we may illustrate the law which regulates the increment of bon by starting from another foundation. Instead of building on rsh-gas, we make use of the oxide of marsh-gas, *methylic alcohol.* is compound by the successive addition of one atom of carbon and two of hydrogen, produces a series of alcohols which may be regarded as the oxides of the corresponding marsh-gas-analogous. The first compound thus obtained is *ethylic alcohol*, ordinary spirits of wine; the second, *propylic alcohol*, generated in the fermentation of the grape-skin residue of the manufacture of wine; the third, *butylic alcohol*, formed by the fermentation of the molasses of beetroot sugar; the fourth, *amylic alcohol*, or potato oil, obtained as a residue in the manufacture of spirit from the starch of potatoes. *Caproic*, *œnanthylic*, and *caprylic*, *alcohols* are further terms of the series, which rises, not without considerable gaps, to terms containing as many as eighteen, twenty-seven, and even thirty atoms of carbon, which are found respectively in *palmitic*, *cerotic*, and *melissic alcohols*: the first, a product of the decomposition of spermaceti; the last two, derived from ordinary bee's wax and Chinese wax.

Increment of Carbon.

ALCOHOLS.

Methylic alcohol	.	CH_4O
Ethylic ,,	.	$CH_4O + CH_2 = C_2H_6O$
Propylic ,,	.	$CH_4O + 2\,CH_2 = C_3H_8O$
Butylic ,,	.	$CH_4O + 3\,CH_2 = C_4H_{10}O$
Amylic ,,	.	$CH_4O + 4\,CH_2 = C_5H_{12}O$
Caproylic ,,	.	$CH_4O + 5\,CH_2 = C_6H_{14}O$
Œnanthylic ,,	.	$CH_4O + 6\,CH_2 = C_7H_{16}O$
Caprylic ,,	.	$CH_4O + 7\,CH_2 = C_8H_{18}O$
. . . .	.	
Palmitic ,,	.	$CH_4O + 15\,CH_2 = C_{16}H_{34}O$
. . . .	.	
Cerotic ,,	.	$CH_4O + 26\,CH_2 = C_{27}H_{56}O$
. . . .	.	
Melissic ,,	.	$CH_4O + 29\,CH_2 = C_{30}H_{62}O$

Again, we may take another compound as point of departure. *Formic acid* is a body long since discovered to be secreted by the ant. By adding an atom of carbon and two of hydrogen to this acid we arrive at *acetic acid*, which we have already met with this evening as one of the products of the oxidation of olefiant gas. By the successive accumulation, within the molecule of this acid, of similar quantities of carbon and hydrogen, a long series of acids is formed, including some of the most interesting compounds with which the chemist has to deal: *butyric* acid, contained in butter; *valeric*, the active constituent of the valerian root; *caproic* and *caprylic*, obtained from goat's fat; *œnanthylic*, from castor oil; *pelargonic*, the odoriferous principle of *pelargonium roseum*; *rutic*, the product of oxidation of oil of rue; *palmitic*, contained in palm oil and in spermaceti; *margaric* and

ric, constituents of the majority of animal fats; *cerotic* and *melissic* **ds**, lastly, occurring in the several waxes.

Increment of Carbon.

ACIDS.

Formic acid	. .	$C H_2 O_2$
Acetic ,,	. .	$C H_2 O_2 + CH_2 = C_2 H_4 O_2$
Propionic ,,	. .	$C H_2 O_2 + 2 CH_2 = C_3 H_6 O_2$
Butyric ,,	. .	$C H_2 O_2 + 3 CH_2 = C_4 H_8 O_2$
Valeric ,,	. .	$C H_2 O_2 + 4 CH_2 = C_5 H_{10} O_2$
Caproic ,,	. .	$C H_2 O_2 + 5 CH_2 = C_6 H_{12} O_2$
Œnanthylic ,,	. .	$C H_2 O_2 + 6 CH_2 = C_7 H_{14} O_2$
Caprylic ,,	. .	$C H_2 O_2 + 7 CH_2 = C_8 H_{16} O_2$
Pelargonic ,,	. .	$C H_2 O_2 + 8 CH_2 = C_9 H_{18} O_2$
Rutic ,,	. .	$C H_2 O_2 + 9 CH_2 = C_{10} H_{20} O_2$
. . . .	. .	. . . .
Lauric ,,	. .	$C H_2 O_2 + 11 CH_2 = C_{12} H_{24} O^2$
Cocinic ,,	. .	$C H_2 O_2 + 12 CH_2 = C_{13} H_{26} O^2$
Myristic ,,	. .	$C H_2 O_2 + 13 CH_2 = C_{14} H_{28} O^2$
Benic ,,	. .	$C H_2 O_2 + 14 CH_2 = C_{15} H_{30} O_2$
Palmitic ,,	. .	$C H_2 O_2 + 15 CH_2 = C_{16} H_{32} O_2$
Margaric ,,	. .	$C H_2 O_2 + 16 CH_2 = C_{17} H_{34} O_2$
Stearic ,,	. .	$C H_2 O_2 + 17 CH_2 = C_{18} H_{36} O_2$
. . . .	. .	. . . .
Cerotic ,,	. .	$C H_2 O_2 + 26 CH_2 = C_{27} H_{54} O_2$
. . . .	. .	. . . .
Melissic ,,	. .	$C H_2 O_2 + 29 CH_2 = C_{30} H_{60} O_2$

The action of the acids just examined upon the groups of alcohols viously studied gives rise, as is well known, to the class of bodies lled compound ethers. On arranging some of the numerous bodies longing to this group into a series in which the carbon rises, atom by m, we find, in exact accordance with our former observations, that accession of one atom of carbon involves the simultaneous introduc-n of two atoms of hydrogen :—

Increment of Carbon.

COMPOUND ETHERS.

Formate of Methyl	.	$C_2 H_4 O_2$
Formate of Ethyl	.	$C_2 H_4 O_2 + CH_2 = C_3 H_6 O_2$
Acetate of Ethyl	.	$C_2 H_4 O_2 + 2 CH_2 = C_4 H_8 O_2$
Butyrate of Methyl	.	$C_2 H_4 O_2 + 3 CH_2 = C_5 H_{10} O_2$
Butyrate of Ethyl	.	$C_2 H_4 O_2 + 4 CH_2 = C_6 H_{12} O_2$
Acetate of Amyl	.	$C_2 H_4 O_2 + 5 CH_2 = C_7 H_{14} O_2$

All these substances present more or less general interest. The powerful, and in some cases almost repulsive odours which the compound ethers possess may be tamed down by dilution, so as to render these substances useful, and indeed extensively applied, substitutes for natural essences. *Formate of methyl*, the simplest of all compound ethers, like the next term, *formate of ethyl*, has received some applications in the flavouring of inferior varieties of rum. *Acetate of ethyl*, familiar to everyone as acetic ether, is used for "improving" certain wines; the *butyrate of methyl* and *ethyl*, substances which undiluted possess an almost overwhelming, and by no means attractive, odour, exhale, when dissolved in an appropriate amount of spirits of wine, the finest perfume of the pine apple; *acetate of amyl*, lastly, the final term of our series, exhibits the peculiar aroma of the jargonelle pear in so high a degree that it is now extensively manufactured to flavour the well-known pear drops of our confectioners.

I must not, however, dilate too much on the odoriferous qualities of the compound ethers; here, indeed, we are concerned with these substances only in so far as they afford additional evidence in favour of our speculations respecting the growth of carbon in a series of carbon compounds.

One more illustration and we shall have done with this part of our inquiry. In a lecture delivered some time ago in this theatre, I had the honour of submitting to the members of the Royal Institution a brief account of *Mauve* and *Magenta*, the remarkable coal-derived colouring matters which have sprung from the happy union of industry and science in our times. May I be permitted once more to call your attention for a moment to the group of tinctorial ammonias? *Aniline red*, or *rosaniline*, as it is called by chemists, is convertible by certain processes into beautiful *violet*, and even *blue* colouring matters. This conversion invariably involves addition of carbon to the molecule of rosaniline. By its conversion into certain varieties of violet, the red fixes six atoms of carbon; by its transition into certain bluish shades, not less than fifteen atoms of carbon are assimilated. In what manner does this increment of carbon affect the amount of hydrogen? Inspection of the diagram teaches us that aniline violet contains 12 = 2 × 6 atoms of hydrogen more than aniline red, and that the transition of red into blue is attended by an accession of as many as 30 = 2 × 15 atoms of hydrogen.

Increment of Carbon.

COLOURING MATTERS.

Aniline red .	$C_{20} H_{21} N_3 O$
Aniline violet .	$C_{20} H_{21} N_3 O + 6\,CH_2 = C_{26} H_{33} N_3 O$
Aniline blue .	$C_{20} H_{21} N_3 O + 15\,CH_2 = C_{35} H_{51} N_3 O$

In the preceding remarks I have submitted to you an extensive
ies of examples taken from different pages in the vast volume of
mistry, which appear to indicate that oxygen combines atom by
m, that nitrogen enters the compound freighted with one atom of
lrogen, and lastly, that carbon cannot join the concern except with a
ital, so to speak, of two atoms of hydrogen. Supposing for a
ment that this rule could be established without a single exception
oughout the whole range of chemistry, are we enabled to assign
robable reason for this peculiar behaviour of the oxygen, nitrogen,
d carbon atoms?

To answer this question we must commence by considering for a
r moments some of the simplest compounds of the elements con-
rned.

Here we have four glass tubes surmounted by large globes. The
st of these contains *hydrochloric acid*, the compound of hydrogen
th chlorine; the second did contain the vapour of *water*, the com-
und of hydrogen with oxygen, but which is now condensed to small
ops of fluid water deposited on the sides of the globe; in the third
sel we have the compound of hydrogen with nitrogen, *ammonia*;
ile the last is filled with one of the compounds of carbon with
drogen, *viz. marsh-gas*.

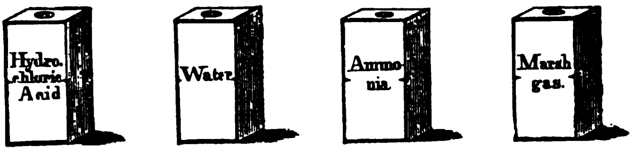
These four compounds, all transparent and colourless, we distin-
ish by the simplest experiments. On opening the sealed tubes
the vessels under mercury no change takes place in the case of
drochloric acid, ammonia, and marsh-gas, while the mercury imme-
tely rises and fills the globe containing the condensed water vapour.
hen the remaining three vessels are now raised, so as to allow the
oken points of the tubes to dip in a layer of water floating on the
rcury, the liquid rushes into the globes containing hydrochloric acid
d ammonia; of the two solutions thus produced by the absorption of
gases, the one containing the hydrochloric acid reddens blue litmus;
other, formed by the absorption of the ammonia, changes red lit-
s to blue. The marsh-gas differs from all the others by its insolu-
ity and by its inflammability. Indeed, if the globe be broken and
ight applied, the gas burns with a feebly luminous flame.

Nor are the differences observed in the structure of these four
drogen compounds less characteristic, although they cannot be so
ily demonstrated by experiment, at all events within the limited
ne at my disposal. Indeed, to give you an idea of their structure
ich is necessary for our purposes, I must be permitted to borrow a
af from the book of the Wizard of the North, and to avail myself of
simple mechanical contrivance devised for that purpose. Let these
ur tin boxes represent two volumes of hydrochloric acid, water-gas,
mmonia, and marsh-gas.

We wish to know the quantities of hydrogen contained in two
olumes of each of these four bodies, and we find that out of the two
volumes of hydrochloric acid we are enabled to pull *one* volume of
hydrogen; out of the same volume of water-vapour, *two* volumes of

hydrogen; out of the same volume of ammonia, by a mechanical contrivance of the simplest description, *three* volumes of hydrogen; and lastly, out of two volumes of marsh-gas, *four* volumes of hydrogen.

FIG. 1.



We now require to know the quantities of the other elements present in the four compounds under examination, and again we extract from the original two volumes of hydrochloric acid *one* volume of chlorine; from the two volumes of water-vapour, *one* of oxygen; from the two of ammonia, *one* of nitrogen; and lastly, from the two volumes of marsh-gas, an amount of carbon which *provisionally* I may be permitted to represent by *one* volume, since, owing to the non-volatility of the carbon, the volume of the carbon vapour has not yet been ascertained.

FIG. 2.

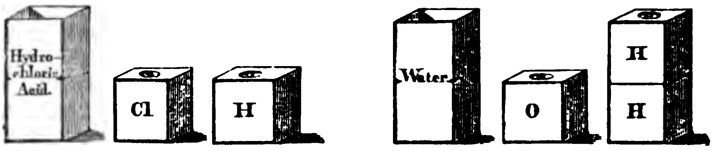
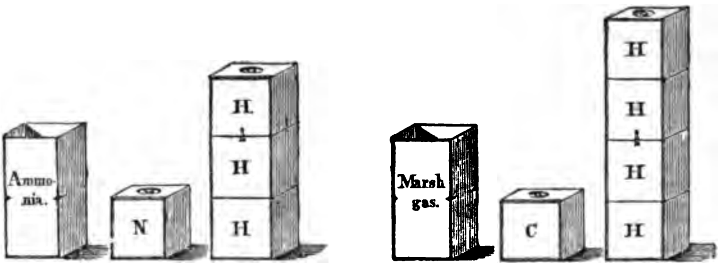
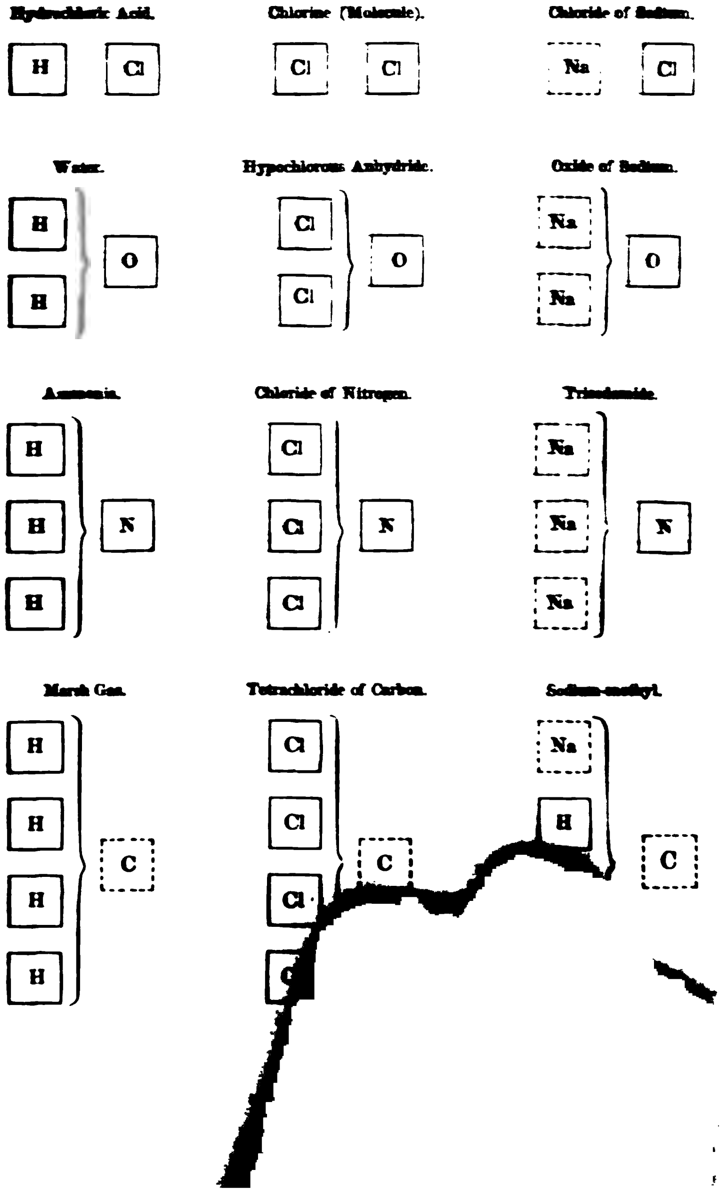


FIG. 3.



The information mechanically conveyed to us by our tin boxes is embodied in the following diagram, which is, moreover, calculated to enlarge our views respecting the combining powers of the elements chlorine, oxygen, nitrogen, and carbon.

Fig. 4.



In the second column of the diagram are given the compounds of these four elements with chlorine, and exactly as we have seen them combining respectively with 1, 2, 3, and 4 volumes of hydrogen, we now find them associated with 1, 2, 3, and 4 volumes of chlorine. Again, in the third column we have the series of sodium compounds of these elements, and although in this case we must be careful not to speak of volumes of sodium-vapour, since chemists have not as yet obtained sodium-gas in the pure state, we perceive at all events from the diagram that one volume of oxygen fixes exactly twice, one volume of nitrogen exactly three times the quantity of sodium which is combined with one volume of chlorine.

The study of elementary gases has led chemists to the unanimous opinion that equal volumes of these different gases contain an equal number of the smallest particles or atoms. Numerous theoretical considerations and numerous experimental inquiries inevitably lead to this result, which is now a generally received truth. If equal volumes of different gases be submitted to the same pressure they contract to an equal extent, and if they are equally heated they expand equally.

We have here an apparatus so disposed as to permit us to establish this point experimentally. It consists of a kind of double U tube, with one long and simple limb, and one short limb bifurcated into two branches, each of which is provided with a stopcock. These short limbs are moreover surrounded by a glass cylinder. Near the bottom of the apparatus another stopcock is placed, enabling us to empty the apparatus. The three limbs of the instrument being filled with mercury, we introduce into the stopcocked limbs the gases to be examined, into the one hydrogen and into the other oxygen, care being taken to have as nearly as possible equal volumes of the two. These volumes being marked by caoutchouc rings we pour mercury into the long open limb, and we find that the mercury column thus obtained compresses the two gases to an exactly equal extent. Again, on letting out mercury through the bottom stopcock, so as to lower the column and diminish the pressure, we observe that both hydrogen and oxygen undergo equal dilatation. And so again we are enabled to prove the expansion and contraction of the two gases to be equal, if the glass cylinder surrounding the bifurcated limb of the apparatus be filled alternately by hot steam or cold air.

Now, if equal volumes of the elementary gases contain an equal number of atoms, it is obvious that

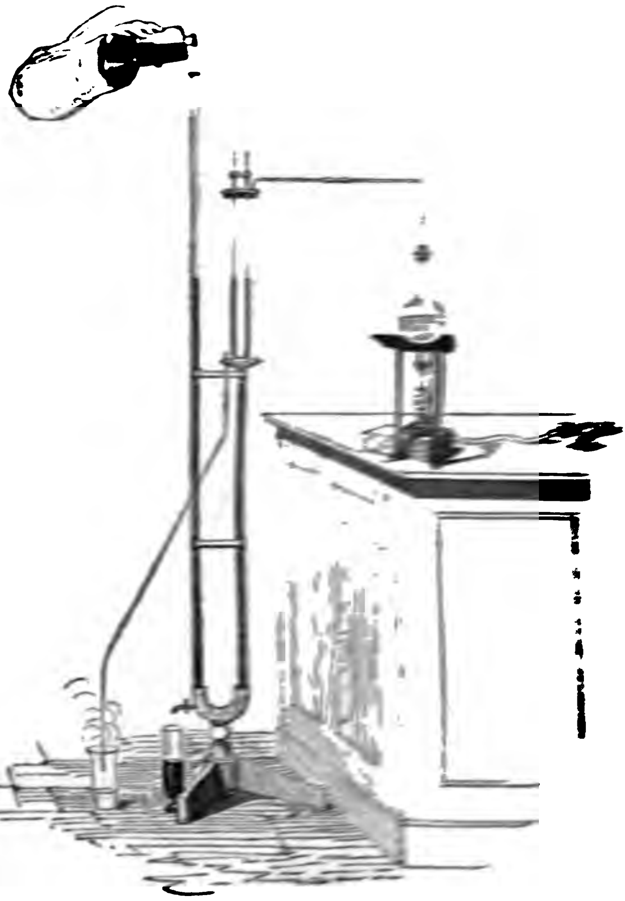
The chlorine atom combines with 1 atom of hydrogen,
,, oxygen ,, ,, 2 atoms ,,
,, nitrogen ,, ,, 3 ,, ,,

and since there are reasons for believing that the quantity of carbon existing in two volumes of marsh-gas (but which, as I have pointed out, has never been obtained in the gaseous state) represents the carbon atom, we may add that

The carbon atom combines with 4 atoms of hydrogen.

in a similar manner we may say that the atoms of the four elements
estion, when uniting with chlorine, are found to be capable of
; 1, 2, 3, or 4 atoms of chlorine.

Fig. 1.



These observations which, if time permitted, might be considerably
nded, lead us to a very important distinction of *elementary atoms*,
h is based upon their *atom-fixing capabilities*, more shortly ex-
sed, upon their *combining powers*.

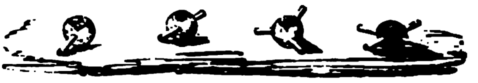
If the atom-fixing power of the chlorine atom be taken as standard
mparison, we are compelled to assign to the oxygen atom the two-
, to the nitrogen atom the threefold, and [illegible] atom the

fourfold atom-fixing power: or, looking at this question from a different point of view, we find that one atom of oxygen is performing the work of two atoms of chlorine; one atom of nitrogen, that of three; one atom of carbon, lastly, that of four atoms of chlorine. Hence we distinguish the chlorine atom as *univalent*, the atom of oxygen as *bivalent*, that of nitrogen as *trivalent*, and, lastly, the carbon atom as *quadrivalent*.

With the recognition of these different combining powers in elementary atoms we have made a very considerable step towards the solution of the question which presented itself in the earlier part of this discourse, *viz.*: How is it that the oxygen atom is fixed directly, the nitrogen atom together with one, the carbon atom, lastly, together with two atoms of hydrogen? This peculiar mode of combination is the necessary consequence of the special atom-fixing capabilities of the oxygen, nitrogen, and carbon atoms; and this I believe I can show you by a very simple contrivance. I am again tempted to rely entirely on mechanical means of elucidating the subject, and I will on this occasion, with your permission, select my illustration from that most delightful of games, *croquet*.

Let the croquet balls represent our atoms, and let us distinguish the atoms of different elements by different colours. The white balls are hydrogen, the green ones chlorine atoms; the atoms of fiery oxygen are red, those of nitrogen, blue; the carbon atoms, lastly, are naturally represented by black balls. But we have, in addition, to exhibit the different combining powers of these atoms. This we accomplish by screwing into the balls a number of metallic arms (tubes and pins), which correspond respectively to the combining powers of the atoms represented, and which, while constituting an additional feature of distinction, enable us at the same time to join the balls and to rear in this manner a kind of mechanical structures in imitation of the atomic edifices to be illustrated. Thus the hydrogen and chlorine atoms, which are univalent atoms, have each *one* arm, representing *one* combining or attractive unit; the atom of oxygen, a *bivalent* atom, has *two*, representing two attraction units; while the nitrogen and carbon atoms, respectively trivalent and *quadrivalent*, are provided with *three* and *four* arms, indicating the *three* and *four* combining units respectively distinguishing these atoms.

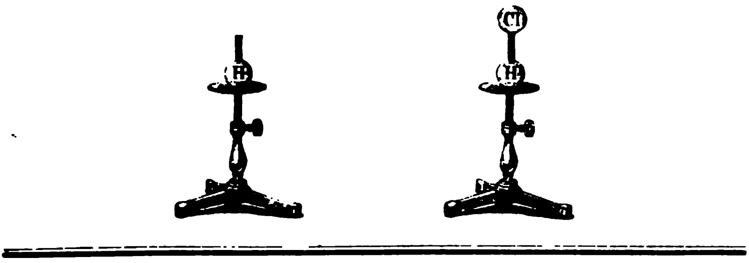
FIG. 6.



Of the newly-formed building materials let us make a preliminary trial in constructing the four hydrogen compounds just examined.

We start with four appropriately disposed stands as a foundation, on each of which we place a hydrogen sphere as the first building stone. On one of these hydrogen atoms we fix a chlorine atom by inserting the solid arm of the former into the tubular arm of the latter, we have thus constructed a molecule of hydrochloric acid. The attraction units of the two elements are saturated; we can add no more; the building is finished.

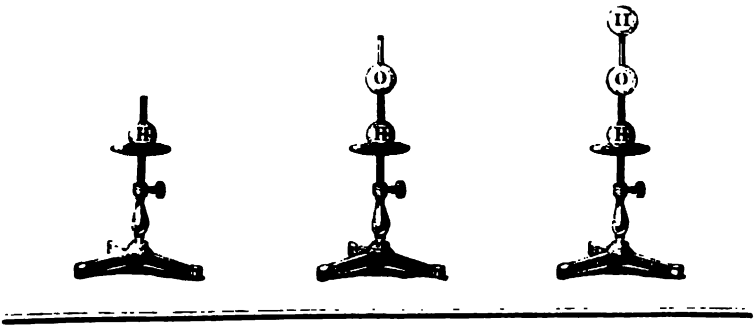
Fig. 7.



Formation of Hydrochloric Acid.

The next hydrogen atom we combine in a similar manner with an atom of oxygen, but no closed molecule is thus produced. One of the attraction units of the oxygen is not yet saturated, as indicated by the one arm remaining uncovered. Only by fixing upon this arm a second hydrogen atom we saturate this second attraction unit also. The closed water molecule is a finished building.

Fig. 8.

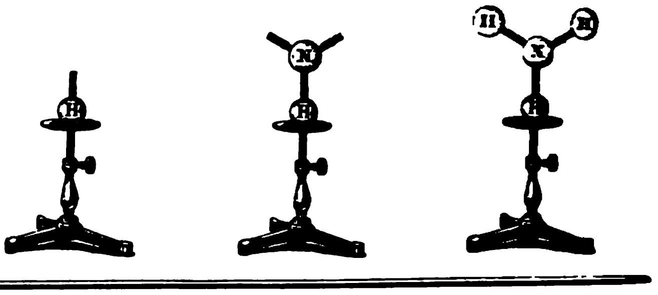


Formation of Water.

Again, an atom of nitrogen is inserted into the hydrogen atom on our third stand; the two nitrogen arms which are left exposed sufficiently indicate that two attraction units remain unsaturated, and have accordingly to be provided with two atoms of an univalent element.

If this univalent element be hydrogen, the finished structure is the molecule of ammonia.

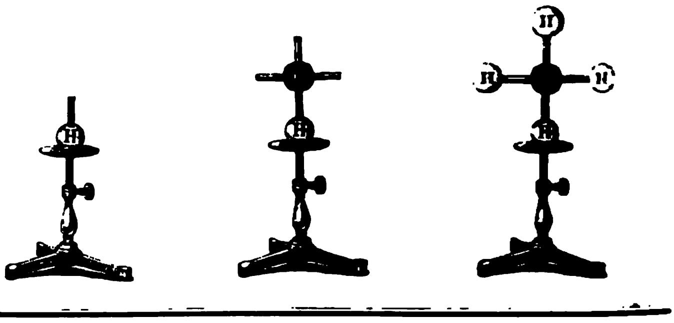
Fig. 9.



Formation of Ammonia.

In a similar manner, lastly, we perceive that when a four-armed carbon atom is fixed upon the hydrogen atom, the three combining units remain unsaturated, and that the construction of a closed molecule of marsh-gas can be accomplished only by the accession of three atoms of hydrogen.

Fig. 10.



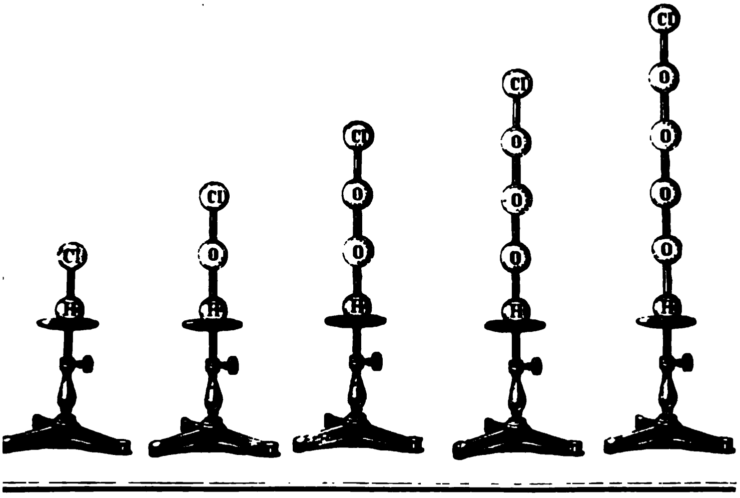
Formation of Marsh-gas.

At this stage we may appropriately resume the question suggested by the earlier considerations of this evening. The facility with which our newly-acquired building material may be handled, enables us to construct even some of the more complicated substances involved in these considerations.

And first, the building up of the oxygen compounds of hydrochloric acid may be attempted. On opening the molecule of ***hydrochloric acid***, two attraction units (one belonging to the hydrogen atom, and the other to the chlorine atom,) are liberated ; they are exactly equal to the two attractions of the bivalent atom of oxygen. With the insertion of an oxygen atom we perceive that the molecule is closed again, no uncovered arm projects, no attraction remains unbalanced. This new molecule—we call it ***hypochlorous acid***—we open again : again two attraction units are liberated and saturated by a second atom of bivalent oxygen. The molecule of hypochlorous acid is thus converted into the molecule of ***chlorous acid***. The insertion of one or two more oxygen atoms under exactly similar circumstances would give rise to the formation of the molecules respectively of ***chloric*** and of ***perchloric*** acids.

We are thus enabled, by availing ourselves exclusively of oxygen as building material, to convert the two-storied molecule of hydrochloric acid successively into a three-, four-, five-storied molecule, and ultimately even into the six-storied molecule of perchloric acid ; and here is no reason why a happy experimentalist, by using additional nd more complicated scaffolding, should not succeed in raising still oftier structures.

FIG. 11.

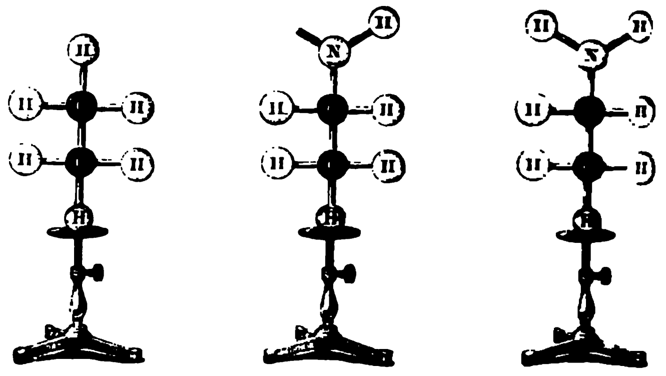


HYDROCHLORIC ACID. HYPOCHLOROUS ACID. CHLOROUS ACID. CHLORIC ACID. PERCHLORIC ACID.

The reason why, when uniting with a compound, oxygen joins this compound, atom by atom, is now obvious. By opening a finished molecule, two attraction units are set free ; these may be balanced by one atom of oxygen, but also by a chain of two, three, four, in fact of any number of oxygen atoms. Of the two, four, six, eight, &c. attraction units possessed by one, two, three, and four atoms of oxygen, two, four, and six units are consumed in linking these atoms into a chain, so that only two units, one at each end of the chain, remain at our disposal, and may be used in closing up again the broken molecule.

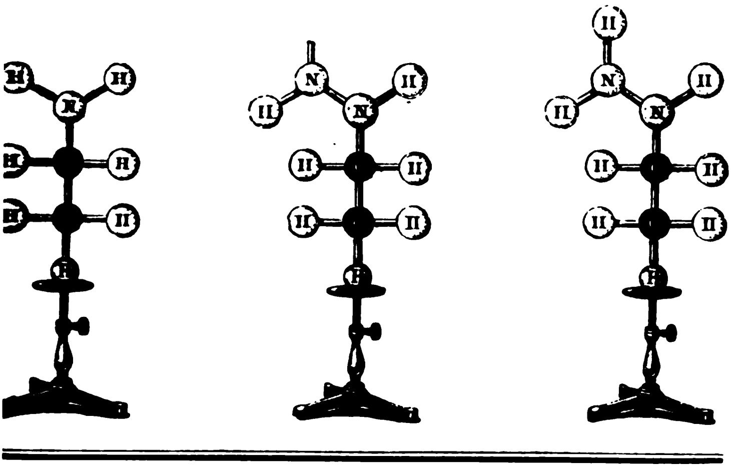
Not less satisfactory is the information supplied by the consideration of a series of nitrogenetted compounds. In *hydride of ethyl* we possess a molecule containing two atoms of carbon and six atoms of hydrogen. With the view of introducing an atom of nitrogen we break this molecule. A glance at our model shows us at once, that by inserting between the fragments a nitrogen atom only, we are unable to reproduce a finished building, for of the three attraction units with which the nitrogen atom enters, two only are saturated; one remains unsaturated, indeed one nitrogen arm projects uncovered. It is only by addition of another atom of hydrogen that the closed molecule of *ethylamine* is formed. This molecule again we open, again we introduce an atom of nitrogen, and again we observe that one attraction unit of the newly-added atom remains unsatisfied, and that an additional atom of hydrogen is required for the transformation of ethylamine into *ethylene-diamine*, and so again when ethylene-diamine is to be converted into *vinyltriamine*.

FIG. 12.



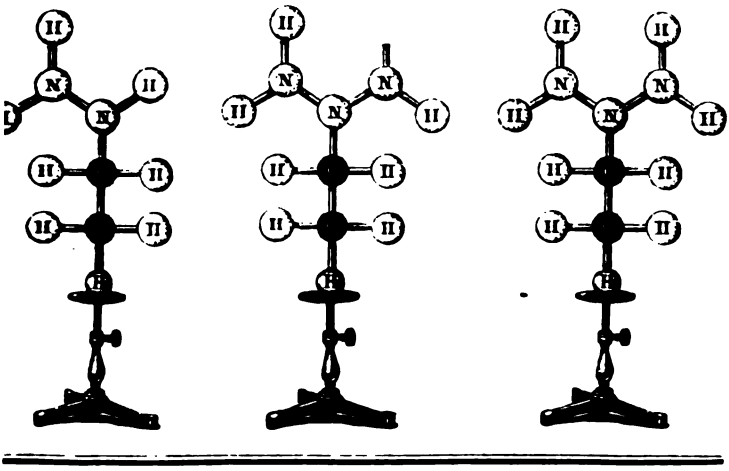
HYDRIDE OF ETHYL. ETHYLAMINE.

Fig. 13.



Ethylamine. Ethylene-diamine.

Fig. 14.



Ethylene-diamine. Vinyltriamine.

Why the nitrogen atom does not combine directly, like the atom of oxygen, but always carries an atom of hydrogen along with it, is now likewise demonstrated. If a finished molecule be broken for the reception of a new atom, the number of combining units liberated is always two. This, as we have seen, is the number which is saturated by one atom of oxygen, or by a chain of oxygen atoms; but when these two attraction units are saturated by a nitrogen atom, one of the attraction units of the nitrogen remains free; when they are saturated by a chain of nitrogen atoms, the number of attraction units remaining free must be equal to the number of atoms composing the nitrogen chain.

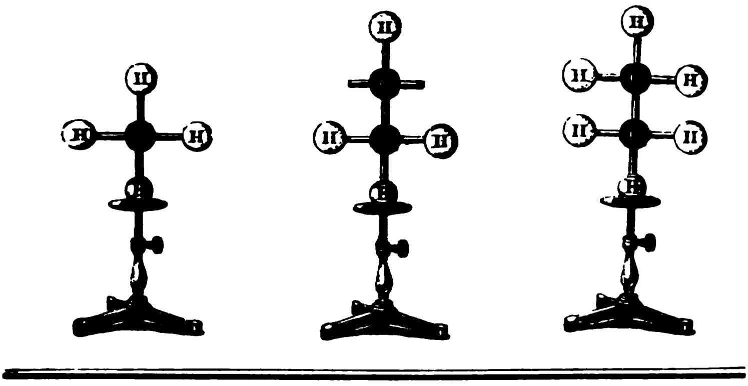
The experience acquired in the study of the oxygen and nitrogen compounds has prepared us for the examination of the increment of carbon. In fact, it is only necessary to apply the method hitherto followed to one of the series of carbon compounds already reviewed, to enable us to understand why the carbon atom is assimilated, not atom by atom, like the oxygen atom, not associated with *one* atom of hydrogen like the nitrogen atom, but associated with *two* atoms of hydrogen.

We have only to remember that the carbon atom saturates *four* combining units, while the nitrogen atom saturates only *three*. Now, we have seen that the rupture of a molecule involves the liberation of two attraction units. The saturation of these two units by the trivalent nitrogen atom left 3—2=1 attraction unit disengaged; in a similar manner, if the saturation be effected by the quadrivalent carbon atom, 4—2=2 attraction units must remain unsaturated.

The reason why the carbon atom, when fixed by composition, associates with two atoms of hydrogen,—why so large a number of carbon compounds differ by CH_2, or a multiple thereof,—in fact the relation in the composition of numerous series of carbon compounds which is designated by the term *homology*, is now intelligible.

In attempting to illustrate this behaviour of the carbon atom by our mechanical models, we conveniently select the molecule of *marsh-gas*, the simplest compound of carbon and hydrogen, as the foundation of our edifice. This molecule we open for the insertion of a second carbon atom. The two attraction units liberated by the rupture of the molecule are saturated by two of the attraction units of the quadrivalent carbon atom, two attraction units of which remain unsaturated. Indeed two carbon arms remain uncovered, on which we forthwith fasten two atoms of hydrogen. The transformation of marsh-gas into *hydride of ethyl* is thus accomplished.

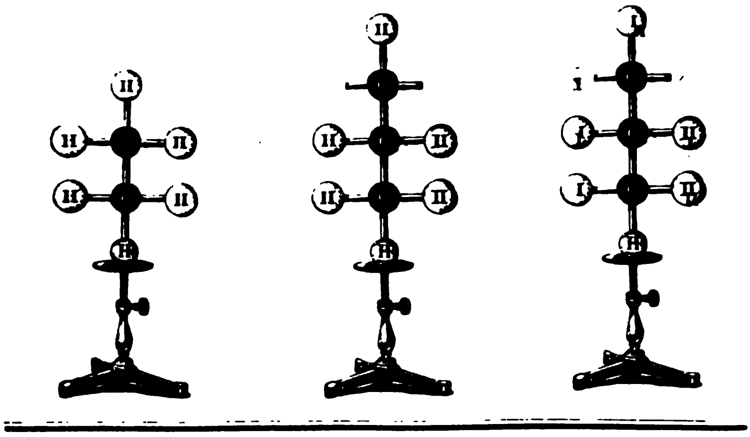
FIG. 15.



MARSH-GAS. HYDRIDE OF ETHYL.

We open again for the reception of another atom of carbon, and this third atom joins under exactly the same circumstances, carrying along with it into the new molecule, the spaces, so to speak, for two additional atoms of hydrogen. Hydride of ethyl in this manner becomes *hydride of propyl.*

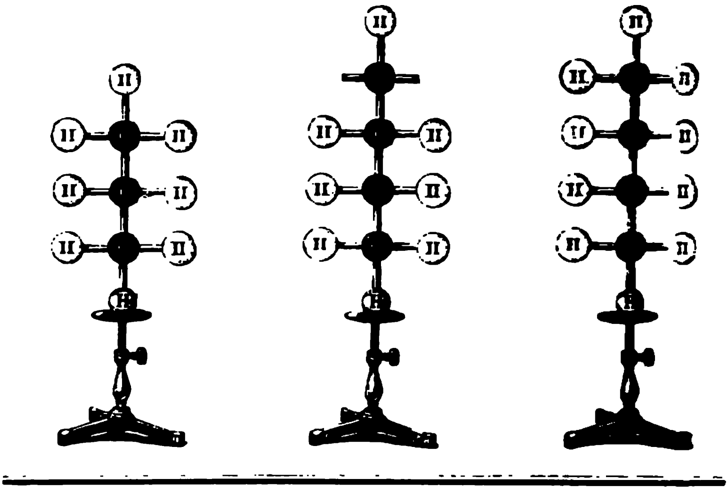
FIG. 16.



HYDRIDE OF ETHYL. HYDRIDE OF PROPYL.

Hydride of propyl, by the accession of a fourth carbon atom, is converted into *hydride of butyl.*

FIG. 17.



HYDRIDE OF PROPYL. HYDRIDE OF BUTYL.

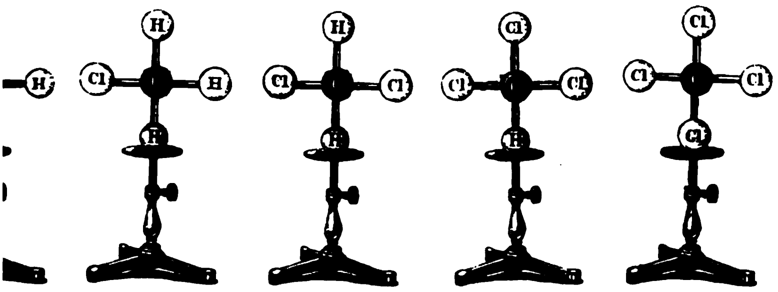
It is scarcely necessary to expand these illustrations, and if I venture to raise up a few more of these mechanico-chemical edifices, it is because I want to show you that our building stones are available for many other purposes.

Hitherto we have been satisfied with examining under what conditions the atoms of oxygen, of nitrogen, and carbon are received into molecular structures. The question now presents itself, on what terms the chlorine atom is allowed to join?

The model of the marsh-gas molecule is still before us. Let us open this molecule for the reception of a chlorine atom. Two attraction units are thus liberated; but the chlorine atom is univalent. Accordingly two atoms of chlorine are required, one of which combines with the hydrogen atom which we remove from the marsh-gas, converting it into hydrochloric acid which separates, while the other chlorine atom joins the rest of the molecule of marsh-gas. The new molecule, *monochlorinetted marsh-gas*, may be looked upon as marsh-gas in which one atom of chlorine holds the position originally occupied by the hydrogen atom. We are thus led up to the recognition of new conditions of combination, conditions which have not as yet attracted our attention this evening, but which unfold to us one of the

st important principles of modern chemistry, the principle of *substi-*
on. The monochlorinetted marsh-gas, which is a liquifiable gas,
n again submitted to the action of chlorine loses a second, a third,
lastly, a fourth atom of hydrogen in the form of hydrochloric
l, giving rise to the formation of *dichlorinetted*, *trichlorinetted*
rsh-gas, better known as *chloroform*, and, lastly, of *tetrachlorinetted*
rsh-gas or *tetrachloride of carbon*, *i. e.* marsh-gas in which the four
ms of hydrogen are displaced by an equal number of chlorine atoms.

FIG. 18.



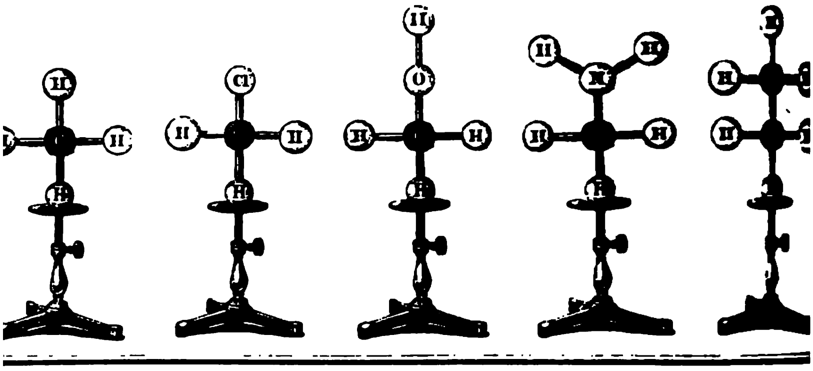
AS. MONOCHLORINETTED MARSH-GAS. DICHLORINETTED MARSH-GAS. TRICHLORINETTED MARSH-GAS. TETRACHLORINETTED MARSH-GAS.

Our information regarding the combining powers of atoms is thus
erially expanded. Having already learnt that when entering into
olecular structure the carbon atom associates with *two* atoms of
rogen, the atom of nitrogen with *one* atom of hydrogen, that the
gen atom combines *directly*, we now find that the chlorine atom
bines only by *substitution*, *i. e.* when a space has become vacant
he molecule by the expulsion of hydrogen.

The rest of the marsh-gas molecule remaining after the introduc-
of one atom of chlorine, and consisting of one atom of carbon,
bined with three atoms of hydrogen, is frequently designated by
name of *methyl*. The aggregate of atoms CH_3, the radical methyl,
be traced in all the compounds obtainable from marsh-gas by the
rtion of other atoms. Thus by the assimilation of an oxygen atom,
sh-gas becomes methylic alcohol, *i. e.* water in which one atom
hydrogen is displaced by methyl, by the absorption of nitrogen
h its tributary hydrogen, it becomes methylamine, *i. e.* ammonia in
ich one atom of hydrogen is displaced by methyl; by the incor-
ation of an atom of carbon, lastly, with its pair of hydrogen atoms,
marsh-gas molecule is converted into methyl-marsh-gas, *i. e.* marsh-
in which an atom of hydrogen is displaced by methyl.

At one time the exertions of chemists were anxiously directed to the isolation of the atomic aggregate CH_3, of the radical methyl,

FIG. 19.



HYDRIDE OF METHYL. CHLORIDE OF METHYL. HYDRATE OF METHYL, AMIDE OF METHYL. METHIDE OF METHYL.

from one or other of the methylic bodies just enumerated. The facility with which the chlorine atom in chloride of methyl may be exchanged for other atoms, leaving the aggregate of carbon and hydrogen, which we call methyl, perfectly intact, the mobility of one of the hydrogen atoms in methylic alcohol, and of two of the hydrogen atoms in methylic ammonia, the possibility of replacing even the oxygen and the nitrogen in these compounds, without affecting the methyl, the stability, lastly, of methylic marsh-gas, containing as it does the whole of its carbon and the whole of its hydrogen in the form of methyl, all these circumstances appeared to indicate the probability of the separate existence of methyl. Why all attempts to separate the atom group CH_3 have remained unsuccessful; why methyl could not be caught; why, ultimately when Dr. Frankland's masterly experiments appeared to have precluded all chance of escape, despairing methyl combined with itself, surrendering as methylic marsh-gas or methyl-methyl; why, in fact, it would appear to be an essential character of methyl not to have a separate existence: all these questions are readily answered by our *croquet* balls, which exhibit us methyl as an unfinished molecule, capable of conversion into the finished molecules, hydride, chloride, hydrate, amide and methide of methyl, but not capable of existing as a molecular fragment with imperfectly balanced attractions.

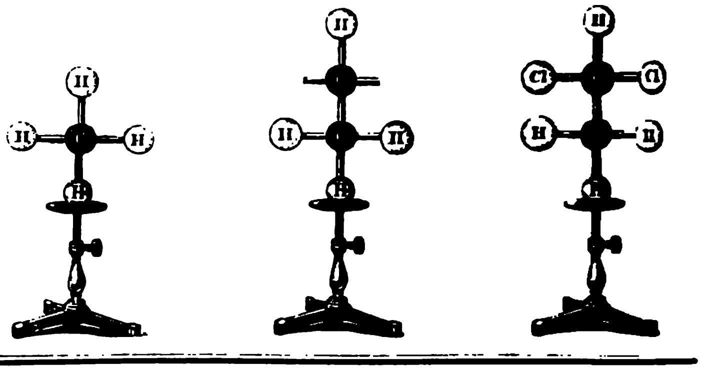
Taking a farewell glance at the results we have elicited this evening, we may fairly ask whether the experience collected on a comparatively limited area is fully and unequivocally corroborated by the examination of a more expanded range of observations? To this question we cannot unhesitatingly give an affirmative answer. It would not be difficult to quote a number of substances, the construction of which appears to have been governed by rules of combination different from those which we have endeavoured to lay down. Indeed, we need not even go beyond the circumscribed field on which we have hitherto moved to meet with prominent cases of exception.

Among the several compounds of carbon and hydrogen which have passed through our hands this evening, we remember the two simplest, *marsh-gas* and *olefiant gas.* In the marsh-gas molecule CH_4, we have the carbon atom completely saturated with hydrogen; by the entrance of a second carbon atom, with its two accessory hydrogen atoms, we saw the molecule of marsh-gas, or hydride of methyl, converted into the molecule of hydride of ethyl C_2H_6.

The formula of olefiant gas, C_2H_4, places its molecule midway between the molecules of marsh-gas and hydride of ethyl. Comparing olefiant gas with marsh-gas, we find that it contains one of carbon more than the latter, the number of hydrogen atoms being equal in both substances. Contrary, then, to the rule on which we hitherto relied, we find that the carbon atom transforming the marsh-gas molecule into the molecule of olefiant gas, enters *without* carrying along the two atoms of hydrogen, which we had accustomed ourselves to consider as the inseparable companions of the carbon atom on such occasions. While frankly admitting that in olefiant gas we meet with the first exception to a rule hitherto unbroken, we are entitled to inquire whether there are no means of explaining this anomalous construction of the olefiant gas molecule. Let us again apply to the models which, in a measure, have assisted us in constructing the rule; perhaps they may help us also in elucidating the exception.

In building up the molecule of olefiant gas by the insertion into the marsh-gas molecule of one atom of carbon only, we obtain what hitherto we would have called an *unfinished* molecule, *i.e.* a molecule in which two of the attraction units of the second carbon atom are unsatisfied. Indeed, a glance at our model shows us that two carbon arms project uncovered. We are thus led to inquire whether unfinished molecules, *i.e.* molecules in which a certain number of attraction units remain unbalanced, are capable of a separate existence. This question is accessible to experiment. Olefiant gas, indeed, possesses all the characters which, granting for argument's sake the possibility of its existence, we are inclined to attribute to an unfinished molecule. In the cases hitherto considered, we saw the chlorine atom, when admitted into a molecular structure, always entering *with substitution*, hydrogen separating from the chlorinetted molecule in the form of hydrochloric acid. In this manner we succeeded in transforming the marsh-gas molecule successively into monochlorinetted, di-, tri-, and, lastly, tetrachlorinetted marsh-gas or tetrachloride of carbon. Submitting, on the contrary, olefiant gas to the action of chlorine, we find that the chlorine is fixed *directly, without substitution*, the chlorine atoms meet,

FIG. 20.



MARSH-GAS. OLEFIANT GAS. DUTCH LIQUID.

so to speak, with vacant spaces existing in the olefiant gas molecule; in order to get in, they need not expel a corresponding number of hydrogen atoms to make room for them. The compound generated is the so-called *Dutch liquid*, an oily substance first produced by an association of Dutch chemists at the close of the last century. It was the production of this oily liquid that gave rise to the name of *olefiant gas*. The number of chlorine atoms thus received directly without substitution is *two*, corresponding exactly with the number of attraction units that remained unsaturated. Any further number of chlorine atoms are found to enter by substitution, and by substitution only. Similar phenomena are observed when olefiant gas is brought into the presence of bromine. We have here a large glass vessel containing some bromine and water; the vessel, by means of a flexible tube, is connected with a gasholder filled with olefiant gas. On agitation, we see the olefiant gas rushing into the vessel as into a *vacuum*. The olefiant gas fixes two atoms of bromine, being converted into a transparent colourless liquid, the substance called *dibromide of olefiant gas*. Here again the combination takes place without substitution.

The behaviour of olefiant gas, under the influence of chlorine and bromine, elucidates the nature of its molecule. The facility with which this gas is capable of fixing two atoms of chlorine to become Dutch liquid, two atoms of bromine to become bromide of olefiant gas, and by roundabout processes two atoms of hydrogen to become hydride of ethyl—all three finished molecules—characterizes olefiant gas as a molecule interrupted in its growth, and in which the power of resuming this growth, and the limit of its final development, may be traced by the simplest experiments. The apparently anomalous construction of the olefiant gas molecule is thus most satisfactorily accounted for. Indeed, far from disturbing the harmony of the rules of combination elicited by our inquiries, a closer examination into the nature of this compound, whilst explaining whatever appeared exceptional in its construction, leads us, on the contrary, to a loftier interpretation of these rules, to the conception of compounds, the very structure of which foreshadows the more prominent features of their chemical character.

I have selected olefiant gas as an example of a class. We remember that this substance is the first term of a long list of homologous bodies, in all of which we find similar structure combined with similar chemical properties. All these substances, and, let me add, a great variety of others, we have to regard as molecules arrested under special circumstances at a certain stage of their development, but capable, under favourable conditions, of growing again, until by the perfect balance of the atomic attractions within, they have ultimately arrived at maturity.

We have thus been led, step by step, to a distinction of a novel kind, that of *finished* and *unfinished* molecules; or, to use the more frequently employed expression, that of *saturated* and *non-saturated* compounds. I need not tell you that this distinction carries us to the threshold of a new field of research, hitherto crossed only by a small band of fearless pioneers, who are encountering difficulties on all sides. Admitting, as we are compelled to do, the existence of what we have called unfinished molecules, we inquire under what special conditions, at what special stages the growth of a molecule may be arrested? How is it that as yet the marsh-gas molecule is known only in the finished state, CH_4, that none of the fragmentary marsh-gases, CH_3, CH_2, and CH_1, which might exist, have ever been obtained? Again, how is it that the molecule of hydride of ethyl exists, so to speak, finished and unfinished; and, lastly, that of the several fragmentary states in which this molecule might be met with, two only, namely the two states, C_2H_4 (olefiant gas), and C_2H_2 (acetylene), have ever been observed? We are thus brought face to face with some of the most deeply interesting problems of chemical mechanics, in the solution of which the exertions of chemists are engaged at the present moment. I must not, however, dwell upon the interest attached to this new line of inquiry, upon the numerous experiments which the idea of saturated and non-saturated compounds has already suggested, and on the influence it is likely to exercise on the direction of chemical investigation for some time to come.

Nor am I permitted to follow these speculations into another direction. I have to forego, more especially, the pleasure of submitting to you some of the ingenious explanations which Professor Kekulé, to whom we are greatly indebted for the development of this branch of chemistry, has advanced for the elucidation even of *saturated* compounds of anomalous constitution. Tempting though the further elaboration of this subject may appear, it would lead me inevitably beyond the legitimate limits of a Friday evening lecture at the Royal Institution.

Indeed my time, and, I fear, your patience, are exhausted, and I must add but few concluding words. Your attention so kindly bestowed on my remarks will not, I trust, have been entirely thrown away, if I have succeeded in convincing you that modern chemistry is not, as it has so long appeared, an ever-growing accumulation of isolated facts, as impossible for a single intellect to co-ordinate as for a single memory to grasp.

The intricate formulæ that hang upon these walls, and the boundless variety of phenomena they illustrate, are beginning to be for us as a labyrinth once impassable, but to which we have at length discovered the clue. A sense of mastery and power succeeds in our minds to the sort of weary despair with which we at first contemplated their formidable array. For now, by the aid of a few general principles, we find ourselves able to unravel the complexities of these formulæ, to marshal the compounds which they represent in orderly series; nay, even to multiply their numbers at our will, and in a great measure to forecast their nature ere we have called them into existence. It is the great movement of modern chemistry that we have thus, for an hour, seen passing before us. It is a movement as of light spreading itself over a waste of obscurity, as of law diffusing order throughout a wilderness of confusion, and there is surely in its contemplation something of the pleasure which attends the spectacle of a beautiful day-break, something of the grandeur belonging to the conception of a world created out of chaos.

[A. W. H.]

WEEKLY EVENING MEETING,

Friday, April 28, 1865.[*]

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. Vice-President, in the Chair.

Dr. Lyon Playfair, C.B. F.R.S.

On the Food of Man in relation to his Useful Work.

HIS discourse was in three divisions. The first division treated of he amount of food required for mere subsistence; then for the full ealth of the non-labouring adult; and lastly, of the quantity necessary or an active labourer. The second division of the discourse discussed he question whether there was sufficient potential energy in the nitroenous tissues, and in the oxygen required for their transformation, to ccount for the dynamical actions within or without the body. The uestion as to whether the fatty and amylaceous ingredients of the ood co-operated in this work was brought under review. The third ivision of the discourse treated of the secretions *per vesicam* and *per num* as measures of work.

In the first division of the discourse a number of subsistence and ow dietaries were recorded, and, as a general average, the following iets were given in ounces of 437½ grains:—

	Subsistence Diet, oz.	Diet in Quietude, oz.
Flesh formers	2·0	2·5
Fat	0·5	1·0
Starch, &c.	12·0	12·0
Starch equivalent of Heat given .	13·2	14·4
Carbon in the Food	6·7	7·4

The speaker then examined the food of soldiers during peace as giving a fair average of food required by adult men, of soldiers engaged n work like the Royal Engineers, and of those exposed to the fatigues f war, as giving diets necessary for labourers. The following averages ere given in ounces:—

	Soldiers during peace.	Royal Engineers.	Soldiers during war.	Active labourers.
Flesh-formers . .	4·2	5·1	5·4	5·6
Fat	1·4	2·9	2·4	2·3
Starch, &c. . .	18·7	22·2	17·9	20·4
Starch equivalent .	22·4	29·4	23·5	25·9
Total carbon . .	11·6	14·8	12·7	13·9

---

[*] This discourse has since been published *in extenso* by Edmonston & Douglas, Edinburgh.

Active labour was defined to consist of work which would enable a man to walk twenty miles every day throughout the year, except on Sundays. The labour during war is much the same, for soldiers marching fourteen miles daily, with 60 lbs. weight of accoutrements, exercise labour amounting to 776,160 foot pounds, while the pedestrian walking twenty miles exerts a force of 792,000 foot pounds.

In the second division of the discourse, the speaker showed that the common experience of mankind is in favour of the nitrogenous ingredients of food being the source of dynamical work. Horses and men, when labouring, are provided with food rich in such substances, and their labour was shown by numerical data to be proportional to the amount of the former. Thus the work of a horse, divided by the work of an ox, gives the ratio 1 : 1·43, while the plastic food of these animals, treated in the same way, yields 1 : 1·44. In the same way, the work of a horse is eight times greater than that of a man, and the plastic food used for the external dynamical labour of each is nearly in the same proportion. The equation of decomposition used by the author is the following one:—

Albumen. Urea or amido-carbonic acid. Carbonic acid. Water.

$$C_{24}\,H_{38}\,N_{6}\,O_{16} + 100\,O = 3\,(CO_{2}\,(NH_{2})_{2}) + 21\,CO_{4} + 13\,(H_{2}\,O_{2}$$

In this equation, the small quantity of sulphur in albumen is viewed as oxygen. The simplicity of the equation is remarkable; for of the two forms of carbonic acid produced, the one, amido-carbonic acid, passes away *per vesicam*, and gaseous carbonic acid *per halitem*. Seven times as much carbon should appear in the latter as in the former secretion, and this is exactly what has been found in the case of dogs fed with flesh free from fat. Using Andrew's units of heat and the above equation, one ounce of transformed tissue (28·35 grammes) would raise 126·5 kilogrammes of water, 1° C., or converted into its mechanical equivalent by Joule's number 425, would raise 53,762 kilogrammes one metre high.* These numbers are easily applied. Soldiers during peace are well exercised by a march of seven miles daily. Their useful external work is therefore 38,333 metre kilogrammes: while the potential energy in the 3·94 oz. of flesh-formers (remaining after deducting the amount in the alvine evacuations) is 211,822 metre kilogrammes. But the internal dynamical work of the heart, respiratory and other movements, require 107,524 metre kilogrammes, so that the residue of 104,298 metre kilogrammes represents nearly three times as much potential energy as useful work. The same method of calculation being applied to a labourer, shows that the 3·5 oz. of flesh-formers applied to external dynamical work, would, after deduction, yield

---

* In this estimation the carbon in urea is supposed to be oxidized into carbonic oxide; but it would be still more in favour of the view if urea were taken as the residue, and six atoms more of hydrogen were oxidized

172,125 metre kilogrammes, the useful work of the labourer being 109,496 metre kilogrammes.

The speaker then showed that the fat contained in the muscles was quite insufficient to account for the useful work done. While the wasted muscles of a non-labouring man would yield 506 kilogramme units of heat, the fat resident in them would give only 87 kilogramme units.

The third division of the discourse treated of the secretions as measures of work. A man living on a subsistence diet should excrete 267 grs. of urea daily, and we find that 264 grs. have been actually found under such circumstances. Soldiers on the diet of peace should have from 560 to 580 grains of urea in their excretions, and the mean of Haughton of 575 grs. represents this quantity. An active labourer ought to have 735 grs. of urea in the urine, and forgemen in engineering works were found to have 740 grains, while active pedestrians were found to have as much as 800 to 850 grs. The same people on days of rest, as on Sundays, had only 500 grs.

The amount of nitrogen secreted *per anum* was viewed as the measure of digestive or assimilative work. One-twelfth of the flesh-formers consumed in food pass away in a state of health in the alvine evacuations as exhausted digestive ferments. These, the speaker contended, were merely slightly oxidized flesh-formers, ready for assimilation and secreted to prepare the food for absorption into the blood. A small portion of them were exhausted in the act, and were then excreted *per anum*, but much the largest portion was reabsorbed into the blood, and was used for the formation of tissues.

In bad digestion, or with excess of food more than one-twelfth of the flesh-formers is necessarily found in the alvine evacuations.

[L. P.]

ANNUAL MEETING,

Monday, May 1, 1865.

William Pole, Esq. M.A. F.R.S. Treasurer and Vice-President, in the Chair.

The Annual Report of the Committee of Visitors for the year 1864 was read and adopted.

The Books and Pamphlets Presented in 1864 amounted to 115 volumes, making, with those purchased by the Managers and Patrons, a total of 436 volumes added to the Library in the Year.

Fifty-one new Members were elected in 1864.

Active labour was defined to consist of work which would enable man to walk twenty miles every day throughout the year, except Sundays. The labour during war is much the same, for soldiers marching fourteen miles daily, with 60 lbs. weight of accoutrements exercise labour amounting to 776,160 foot pounds, while the pedestrian walking twenty miles exerts a force of 792,000 foot pounds.

In the second division of the discourse, the speaker showed that common experience of mankind is in favour of the nitrogenous ingredients of food being the source of dynamical work. Horses and when labouring, are provided with food rich in such substances, their labour was shown by numerical data to be proportional to amount of the former. Thus the work of a horse, divided by the of an ox, gives the ratio 1 : 1·43, while the plastic food of these animals, treated in the same way, yields 1 : 1·44. In the same way, work of a horse is eight times greater than that of a man, and the plastic food used for the external dynamical labour of each is nearly in the same proportion. The equation of decomposition used by the author is the following one:—

$$\begin{array}{ccccccc} \text{Albumen.} & & & & \text{Urea or amido-carbonic acid.} & \text{Carbonic acid.} & \text{Water.} \\ C_{24}H_{38}N_{6}O_{16} & + & 100\,O & = & 3\,(CO_{2}\,(NH_{2})_{2}) & +\,21\,CO_{4} & +\,13\,(H_{2}\,O_{2}) \end{array}$$

In this equation, the small quantity of sulphur in albumen is viewed as oxygen. The simplicity of the equation is remarkable; for of the two forms of carbonic acid produced, the one, amido-carbonic acid, passes away *per vesicam*, and gaseous carbonic acid *per halitum*. Seven times as much carbon should appear in the latter as in the former secretion, and this is exactly what has been found in the case of dogs fed with flesh free from fat. Using Andrew's units of heat and the above equation, one ounce of transformed tissue (28·35 grammes) would raise 126·5 kilogrammes of water, 1° C., or converted into its mechanical equivalent by Joule's number 425, would raise 53,762 kilogrammes one metre high.* These numbers are easily applied. Soldiers during peace are well exercised by a march of seven miles daily. Their useful external work is therefore 38,333 metre kilogrammes; while the potential energy in the 3·94 oz. of flesh-formers (remaining after deducting the amount in the alvine evacuations) is 211,822 metre kilogrammes. But the internal dynamical work of the heart, respiratory and other movements, require 107,524 metre kilogrammes, so that the residue of 104,298 metre kilogrammes represents nearly three times as much potential energy as useful work. The same method of calculation being applied to a labourer, shows that the 3·5 oz. of flesh-formers, applied to external dynamical work, would, after deduction, yield

---

* In this estimation the carbon in urea is supposed to be oxidized into carbonic oxide; but it would be still more in favour of the view if urea were taken as the residue, and six atoms more of hydrogen were oxidized

GENERAL MONTHLY MEETING,

Monday, May 8, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

The President appointed the following Vice-Presidents for the ensuing year:—

Sir Roderick I. Murchison, K.C.B. D.C.L. F.R.S.
William Pole, Esq. M.A. F.R.S.
The Earl Percy, M.P.
The Lord Wensleydale.

Charles Butler, Esq.
William Henty, Esq.
Walter Morrison, Esq. M.P.
George Banks Rennie, Esq.
Arthur Charles Tanqueray, Esq.
Philip D. Tuckett, Esq. F.G.S.

were *elected* Members of the Royal Institution.

The Rev. Tullie Cornthwaite.
Colonel William Lyon.
Alexander McDonald, Esq.

were *admitted* Members of the Royal Institution.

The following Professors were re-elected:—

William Thomas Brande, Esq. D.C.L. F.R.S. Hon. Professor of Chemistry.
John Tyndall, Esq. Ph.D. F.R.S. Professor of Natural Philosophy.
Edward Frankland, Esq. Ph.D. F.R.S. Professor of Chemistry.

The Special Thanks of the Members were returned for the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151):—

Harry Mackenzie, Esq. (*2nd donation*)	£20	0	0
John Carrick Moore, Esq. (*2nd annual donation*) . . .	10	0	0

Sixty-three Lectures and Nineteen Evening Discourses were delivered during the year 1864.

Thanks were voted to the Treasurer and Secretary, to the Committees of Managers and Visitors, to Professor Faraday, and to the other Professors, for their services to the Institution during the past year.

The following Gentlemen were unanimously elected as Officers for the ensuing year:—

President—Sir Henry Holland, Bart. M.D. D.C.L. F.R.S.
Treasurer—William Spottiswoode, Esq. M.A. F.R.S.
Secretary—Henry Bence Jones, M.A. M.D. F.R.S.

Managers.

Sir John Peter Boileau, Bart. F.R.S.
George Busk, Esq. F.R.C.S. F.R.S.
Warren De la Rue, Esq. Ph.D. F.R.S.
Sir George Everest, C.B. F.R.S.
Captain Douglas Galton, F.R.S. F.G.S.
John Peter Gassiot, Esq. F.R.S.
John Hall Gladstone, Esq. Ph.D. F.R.S.
Cæsar H. Hawkins, Esq. F.R.S.
Sir Roderick I. Murchison, K.C.B. D.C.L. F.R.S.
The Earl Percy, M.P.
William Pole, Esq. M.A. F.R.S.
Lewis Powell, M.D. F.S.A.
Robert P. Roupell, Esq. M.A. Q.C.
Joseph William Thrupp, Esq.
The Lord Wensleydale.

Visitors.

John Derby Allcroft, Esq.
John Charles Burgoyne, Esq.
John Peter Gassiot, jun. Esq.
Christopher Darby Griffith, Esq. M.P.
Henry Harwood Harwood, Esq.
Thomas Williams Helps, Esq. M.A.
Thomas Hyde Hills, Esq.
Charles Lyall, Esq.
Harry Mackenzie, Esq.
Edmund Packe, Esq.
The Earl of Rosse, F.R.S. Chanc. Univ. Dublin.
Thomas Harrington Tuke, M.D.
Henry Twining, Esq.
Henry Vaughan, Esq.
Hensleigh Wedgwood, Esq. M.A.

WEEKLY EVENING MEETING,

Friday, May 5, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

Henry Fawcett, Esq.
PROFESSOR OF POLITICAL ECONOMY, UNIVERSITY OF CAMBRIDGE.

On Wealth and Those who Produce it.

[No Abstract received.]

GENERAL MONTHLY MEETING,

Monday, May 8, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

The President appointed the following Vice-Presidents for the ensuing year:—

Sir Roderick I. Murchison, K.C.B. D.C.L. F.R.S.
William Pole, Esq. M.A. F.R.S.
The Earl Percy, M.P.
The Lord Wensleydale.

Charles Butler, Esq.
William Henty, Esq.
Walter Morrison, Esq. M.P.
George Banks Rennie, Esq.
Arthur Charles Tanqueray, Esq.
Philip D. Tuckett, Esq. F.G.S.

were *elected* Members of the Royal Institution.

The Rev. Tullie Cornthwaite.
Colonel William Lyon.
Alexander McDonald, Esq.

were *admitted* Members of the Royal Institution.

The following Professors were re-elected:—

William Thomas Brande, Esq. D.C.L. F.R.S. Hon. Professor of Chemistry.
John Tyndall, Esq. Ph.D. F.R.S. Professor of Natural Philosophy.
Edward Frankland, Esq. Ph.D. F.R.S. Professor of Chemistry.

The Special Thanks of the Members were returned for the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151):—

Harry Mackenzie, Esq. (*2nd donation*)	£20	0	0
John Carrick Moore, Esq. (*2nd annual donation*) . . .	10	0	0

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

From
Actuaries, Institute of—Assurance Magazine. No. 59. 8vo. 1865.
Astronomical Society, Royal—Monthly Notices, 1864–5. No. 5. 8vo.
Atteneo Veneto—Atti. Serie II. Vol. I. Puntata 1. 8vo. 1864.
Bavarian Academy of Sciences, Royal—Sitzungsberichte. 1864: II. 3, 4. 8vo.
Chemical Society—Journal for March, 1865. 8vo.
Editors—American Journal of Science, No. 116. 8vo. 1865.
  Artizan for April, 1865. 4to.
  Athenæum for April, 1865. 4to.
  Chemical News for April, 1865. 4to.
  Engineer for April, 1865. fol.
  Horological Journal for April, 1865. 8vo.
  Journal of Gas-Lighting for April, 1865. 4to.
  Mechanics' Magazine for April, 1865. 8vo.
  Medical Circular for April, 1865. 8vo.
  Pharmaceutical Journal for April, 1865.
  Practical Mechanics' Journal for April, 1865. 4to.
Farina, Il Sac. V. (*the Author*)—Cenno della Grotta Vaporosa e delle Acque Minerali del Monte S. Calogero presso Sciacca. 8vo. 1864.
Fergusson, James, Esq. F.R.S. (*the Author*)—The Holy Sepulchre and the Temple at Jerusalem. 8vo. 1865.
Genève, Société de Physique de—Mémoires. Tome XVII. Partie 2. 4to. 1864.
Geological Institute, Vienna—Jahrbuch: 1864. No. 4. 8vo.
Geological Society—Quarterly Journal, No. 82. 8vo. 1865.
Horticultural Society, Royal—Proceedings, 1865. No. 4. 8vo.
Lankester, Edwin, M.D. F.R.S. M.R.I. (*the Author*)—Second Annual Report of the Coroner for the Central District of Middlesex. 8vo. 1865.
Meteorological Society, British—Proceedings, No. 18. 8vo. 1865.
Petermann, A. Esq. (*the Editor*)—Mittheilungen auf der Gesammtgebiete der Geographie. 1865. Nos. 2, 3. 4to.
Philadelphia Academy of Natural Sciences—Proceedings for 1864. 8vo.
Photographic Society—Journal, No. 156. 8vo. 1865.
Ramstedt, M. Charles (*the Author*)—Dessein et Description d'un Seismomètre. 1865.
Royal Society of London—Proceedings, No. 73. 8vo. 1865.
Royal Dublin Society—Journal, Nos. 32, 33. 8vo. 1865.
Smyth, Admiral W. H. D.C.L. F.R.S. (*the Author*)—Sidereal Chromatics: the Colours of Multiple Stars. 8vo. 1864.
Statistical Society of London—Journal. Vol. XXVIII. Part 1. 8vo. 1865.
United Service Institution—Journal, No. 33. 8vo. 1865.

WEEKLY EVENING MEETING,

Friday, May 12, 1865.

HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

FREDERICK FIELD, F.R.S. L. & E.

On Magenta and its Derivative Colours.

: years ago, in this theatre, Dr. Hofmann delivered his celebrated
rse on Mauve and Magenta, and it might seem temerity in me
pass upon the premises of so great and distinguished a master,
t not remembered that during that interval rapid strides had been
in organic chemistry, and especially, perhaps, in the direction of
iline colours.

though I will endeavour to confine myself as much as possible
immediate subject of the discourse, it will be necessary to glance
ew moments at the history of Aniline, the progenitor of nearly
beautiful compounds you see around the table.

iline was discovered in the year 1826, by Unverdorben, who
ed it from the destructive distillation of indigo. A short time
ards, Runge and Fritsche observed that by the action of strong
e of potash upon the dye, aniline was eliminated in far greater
ty. Indigo in small fragments is heated in a retort with a strong
n of caustic potash, and in the distillate, which consists of many
ts, there is found a thin and nearly colourless fluid, having a
: gravity of 1,028, a peculiar but not disagreeable odour, and a
it biting taste. When kept for some time, even in the dark and
pered bottles, it assumes a darker tint, and becomes ultimately
dark brown. Unverdorben called it "crystalline," Runge
al," and Fritsche "aniline."

is substance is a nitrogenized base, and is capable, when com-
vith acids, of forming those beautiful crystallized salts, nearly
vhich have been carefully examined by Dr. Hofmann and other
s.

ere are many other sources besides indigo, from which aniline
obtained. For commercial purposes it is always prepared
itro-benzol, a substance derived from the action of nitric acid
nzol.

$$C_6H_6 + HNO_3 = C_6H_5NO_2 + H_2O.^*$$

---

* C = 12 — O = 16.

Nitro-benzol when agitated with water, acetic acid, and iron, yields aniline.

$$C_6H_5NO_2 + 6H = C_6H_7N + 2H_2O.$$

Benzol was originally discovered by Mr. Faraday in 1825, in his investigations upon the gaseous products from oils subsequently obtained by the decomposition of benzoic acid by means of caustic lime. Mr. Mansfield, however, succeeded in producing it in much larger quantities from coal-tar naphtha. When the lighter portions of this compound are distilled fractionally until a constant boiling point of 180° F. is arrived at, the product consists of pure benzol, identical with the carbo-hydrogen obtained by Mr. Faraday.

From the earliest discovery of aniline it was noticed that certain oxidizing agents when mixed with a solution of its salts produced a fine violet tint. Even in minute quantities, a few drops of hypochlorite of lime render it purple. There is another test for aniline, which I will show you, and which, as far as I am aware, has not been observed previously. If the red gases obtained by the decomposition of nitric acid by starch or sugar, be passed into an aqueous solution of aniline, the liquid speedily assumes a yellow colour, owing to the formation of a new base—azophenylamine, which is gradually precipitated as a bright yellow powder. It was not, however, until the year 1856 that aniline was applied to any great practical purpose, although from the beauty of its compounds, and from its comparative accessibility, it had from the time of its discovery become a great favourite with chemists.

Mr. Perkin was the first who produced colour on an extensive scale from this base. He added a solution of bichromate of potash to a salt of aniline, and from the precipitate thereby produced, he isolated a magnificent purple dye, he termed "mauve," which at once became popular, and indeed at the time almost universal. It may truly be said that this discovery has identified Mr. Perkin with the aniline colours, and that he will be always associated with one of the most striking and brilliant passages in the history of chemistry as applied to the industrial arts.

It cannot be supposed that such a discovery would be allowed to rest. A mine had been opened which chemists began to explore, and in such numbers, and with such avidity and zeal, as almost to lead us to anticipate that its riches will soon be exhausted. The action of numerous bodies upon aniline and its homologues were found to be productive of colour. Nitrate of silver, nitrate of mercury, chloride of mercury, chloride of tin, arsenic acid, iodine, and many others, when heated with the base, gave a rich crimson colour, in more or less abundance; and, although it would be impossible for me to enter into a disquisition on the comparative merits of these various methods for the production of colour, I trust to be able to produce magenta, although in somewhat crude form, at this lecture table, and also to dye this tassel of silk from a solution of its salt. The reagent I will employ is iodine. A few crystals of this element are placed in a tube with about twice their weight of aniline. Heat is at once evolved, and with the assistance of a higher temperature from the spirit lamp, you will observe, that in a few moments intense colour is developed. If a few drops are now poured into spirit, and this solution added to water, a fine rose-coloured tint will appear.

It may seem strange to those who have read Dr. Hofmann's beautiful researches upon the aniline substitutive products, his chloraniline, bromaniline, iodaniline, and a multitude of others, that he had not observed this curious reaction; and this leads me to tell you, *en passant*, for time will not allow me to dwell upon this interesting topic to-night, that aniline, when perfectly pure, does not yield any amount of colour with most of the reagents mentioned above—a most important fact discovered by Dr. Hofmann and Mr. Nicholson, and which has given rise to one of the most difficult questions which yet remain to be answered. I will simply say that it appears that there must be a homologue of aniline present with that base to produce the colour you see before you, although that homologue, *per se*, will give no colour whatever. Thus, for example, toluidine, $C_7\ H_9\ N$, when treated with oxidizing agents, does not produce colour; let it be mixed with aniline, and the dye is immediately developed.

The tintorial power of the salts of magenta is something marvellous. No dye that I have examined, whether from the animal, mineral, or vegetable world, can bear comparison for one moment with this crimson colour obtained from aniline. One grain in a million times its weight of water gives a pure red, in ten millions a rose pink, in twenty millions a decided blush, and even in fifty millions, with a white screen behind the vessel in which it is dissolved, an evident glow. Magenta has been carefully studied and analyzed by Dr. Hofmann, who gives us the following formula—

$$C_{20}\ H_{21}\ N_3\,O,\ H_2\,O$$

Although the salts of magenta are possessed of such wonderful colouring capacity, the base itself is colourless; and it is remarkable that the union of base and acid for the formation of a salt does not appear to take place in dilute solutions in the cold, at any rate not immediately. In these two vessels, one containing hot and the other cold water, an equal quantity of magenta base is added, and also an equal amount of dilute sulphuric acid. In the hot liquid colour is instantaneously developed; in the cold solution the liquid remains colourless. If now hot water be introduced to raise the temperature, you will observe at once the characteristic rose tint. It may be imagined, therefore, that having free acid in a solution of base without production of colour, it is possible to have free alkali in a coloured solution of a salt of the base without depriving it of its tint. Such is the case. If to a hot solution of acetate of magenta, for example, caustic soda added, the colour is immediately discharged, but in a cold solution colour remains for a long time unchanged.

Dr. Hofmann discovered, about a year ago, that when magenta, or as it is termed in chemical language, rosaniline, is heated with iodide of ethyl, a change is effected, and a substitution product formed, which was termed ethyl-rosaniline. The salts of this new base, unlike magenta, dissolve with a beautiful violet colour, and are capable of affording most remarkable manifestations. The dark violet liquid, on the addition of sulphuric acid, becomes colourless; on adding ammonia the original purple is restored. If hydrochloric acid is added in small quantities, the liquid changes to blue; if in larger quantities, to a brilliant green. When this green solution is thrown into water, so as to dilute the acid, the original violet returns.

When aniline is heated with salts of magenta, purple and blue colours are produced, all of which are now extensively employed in commerce, and afford tints of great brilliancy and beauty. The blue is perfectly insoluble in water, but readily soluble in alcohol, and is capable of dyeing both silk and wool with the greatest facility.

Mr. Nicholson patented a method a few years ago for obtaining a beautiful blue dye, soluble in water, which consisted in heating the phenyl blue in strong sulphuric acid until a drop of the semi-liquid thrown into water was found to be entirely dissolved. This compound, however, although very applicable for silks, refuses to impart its colour to wool, which may be exemplified by immersing two white tassels in the liquid—the silk is immediately dyed, while the wool remains unchanged. The effect is still more striking upon cotton. We have here the letters R. I. (the initials of the Royal Institution) worked in silk upon a cotton ground: after dipping it for a few moments in this bath the letters will become blue, and the cotton continue white.

Aniline green, which has lately become so popular, is produced by the action of aldehyde and some other deoxidizing agents upon rosaniline. This is one of the most charming colours yet discovered, but has not been (as far as its chemical nature is concerned) satisfactorily investigated. To judge of its purity of tint, it is only necessary to compare the commercial greens, prepared by various mixtures of yellow and blue, with the dye in question, to observe the infinite superiority of the latter.

Aniline brown may be formed by the action of chloride of aniline upon either magenta or violet, at a high temperature. Great destruction of colour doubtless takes place, but the brown produced is remarkably beautiful. The compound, however, is not definite, nor can it be classed among the true chemical products derived either from aniline or rosaniline.

It has been observed that magenta base is colourless: this may be said, probably, of the bases of most of the colours before you. On this white board I have traced the letters composing the word "Aniline" in seven colourless bases derived from that compound. A, in ethyl-rosaniline; N, in phenyl-violet, approaching indigo in colour; I, in phenyl-blue; L, in aniline green; I, in azo-phenylamine; N, in chrysaniline; and E, in rosaniline. On converting these bases into salts, which is easily effected by sprinkling them with acetic acid and spirit, the seven letters should be visible in the seven colours of the rainbow—violet, indigo, blue, green, yellow, orange, and red.

I will now throw a beam from the electric lamp upon the specimens of silk on the screen, and it will be observed how much their brilliancy is increased under the influence of that pure and beautiful light. I am indebted to my kind friends, Messrs. Simpson, Maule, and Nicholson, for the various splendid specimens of dye and other aniline products, and to Messrs. Hands, Son, and Co., Coventry, the eminent silk dyers, for the array of silks so kindly furnished me for the illustration of my discourse.

[F. F.]

WEEKLY EVENING MEETING,

Friday, May 19, 1865.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

WILLIAM HUGGINS, Esq. F.R.A.S.

On the Physical and Chemical Constitution of the Fixed Stars and Nebulæ.

THE speaker commenced with a few preliminary remarks on the peculiar relation in which the heavenly bodies stand to man. It is alone from these lights shining upon us from distant space that we can obtain any knowledge of the parts of the universe which are without the earth. The experimentalist who seeks to bring to light the truths which lie hidden beneath terrestrial phenomena, can subject the objects of his research to each other's influence and to the various forms of force; but the astronomer is left to the indications afforded by the sense of sight alone, for the interpretation of the heavens. The distances, magnitudes, and relative motions of the sun, moon, and planets have been obtained with great exactness, but in an important respect our knowledge of the heavenly bodies was at fault. Until quite recently we possessed no knowledge *from observation* of the structure and chemical constitution of the sun, the fixed stars, and the nebulæ. Fortunately, for the increase of our knowledge, the cause of failure lay not in that the light of these bodies is wanting in sufficient indications of their nature, but in that the unaided eye has no power to perceive the indications by which the light of each of the heavenly bodies is specially distinguished.

Newton opened the way to a knowledge of these unperceived qualities of light. He was the first to show that by the refractive power of a prism of glass, the component rays of a beam of light could be separated and presented to the eye as a band of blending colours. Wollaston and Fraunhofer discovered that the colours of the spectrum of solar light are not continuous, but are interrupted by transverse linear spaces where the light is wanting. In these lines of darkness of the solar and stellar spectra, the chemical nature of the sun and stars stands written in cipher, but for half a century the lines of Fraunhofer remained uninterpreted.

In 1859 Kirchhoff announced the law by which these dark lines can be deciphered. He immediately applied his method of interpretation to the light of the sun, and discovered in that body the presence of several of the elementary forms of matter which enter into the composition of the earth.

The speaker stated that it was his intention on this occasion to bring before the members of the Institution the results of the extension of this method of analysis by the prism to the heavenly bodies other than the sun. These researches have been carried on in his observatory during the last three years; and in respect of the greater part of these observations, *viz.* those on the moon, the planets, and the fixed stars, he has had the great pleasure of working conjointly with his distinguished friend, Prof. W. A. Miller.

The speaker then referred briefly to the principles of spectrum analysis, upon which their interpretation of the phenomena observed in the spectra of the heavenly bodies was based, stating that spectra may be arranged under three orders, *viz.*:—

1. *A continuous spectrum unbroken by bright or dark lines*, which indicates that the light has not undergone any modification on its way to us. Also that its source is an opaque body, almost certainly in the solid or liquid state. Such a spectrum gives no information of the chemical nature of the substance from which the light emanates.

2. *A spectrum of bright lines separated by dark spaces*; this informs us that the source of the light is matter in the gaseous state. By a comparison of the bright lines of such a spectrum with the lines of terrestrial flames we may discover whether any of these terrestrial substances exist in the distant and unknown source of light. The spectra of many of the nebulæ are of this order.

3. *A continuous spectrum interrupted by dark lines*; this shows that the light has passed through vapours which have deprived it of certain refrangibilities by a power of selective absorption.

Since Kirchhoff has shown that these dark lines agree exactly in position with the bright lines which the vapours would emit if in a luminous state, a comparison of these dark lines with the bright lines of terrestrial vapours will indicate whether any of these are present in the vapours through which the light has passed. The spectra of the fixed stars are of this order. In the case of these bodies, the vapours that produce the dark lines immediately surround them, and are those of the substances of their surfaces. The chemical constitution of the stellar atmospheres will correspond, at least in part, with that of the stars themselves.

The speaker then described the special form of apparatus by which he and Prof. Miller have compared the spectra of the stars *by a method of simultaneous observation*, with the spectra of many of the terrestrial elements.*

This apparatus is adapted to the eye-end of an achromatic telescope of eight inches aperture. The telescope is mounted equatorially, and follows the star to which it is directed by means of an accurately adjusted clock-motion.

The point of light which a star forms in the focus of the object-glass is lengthened in one direction only by a cylindrical lens. The short line of light falls upon a narrow slit, and the diverging rays are rendered parallel by an achromatic lens. They are then refracted by two prisms of dense flint glass of 60°. The spectrum is viewed with a small achromatic telescope which is carried by a micrometer screw. By means of this the observer can measure with great precision the position of the stellar lines relatively to those of the solar spectrum.

The spectra for comparison were obtained from the spark of an induction coil taken between electrodes of various metals. Sometimes a wire of platinum surrounded with cotton and moistened with a solution of the substance required was employed. The light from the spark is reflected by a small movable mirror upon a reflecting prism covering one half of the slit. By this arrangement the spectrum of the star and the spectrum of the metal compared with it, are seen in juxtaposition, and the coincidence or the relative position of a dark line in the stellar spectrum with a bright line in the metallic spectrum can be determined with very great precision. These comparisons are observations of great delicacy, and can be satisfactorily made on the finest nights only.

Results of the Observations on the Moon and Planets.

MOON.—Limited portions of the moon's surface were examined under varied conditions of illumination. As yet no strongly marked modification of the solar light has been detected, which would indicate a lunar atmosphere of considerable extent. The mode of disappearance of the spectrum of a star when occulted by the moon, is negative as to the existence of an atmosphere about the moon.

---

* It is upon this method of *direct comparison* that the trustworthiness of the results which they have obtained chiefly depends. In this respect too, their observations stand alone. In 1815 Fraunhofer recognized several of the solar lines in the spectra of the Moon, Venus, Mars, and four of the fixed stars. In 1862 Donati published diagrams of three or four lines in fifteen stars. Recently Secchi, Rutherfurd, and the Astronomer Royal have given diagrams of the positions, obtained by measurement only, of a few strong lines in several stars.

JUPITER.—Several lines in the spectrum of Jupiter indicate a powerful absorption by the atmosphere of this planet. These were compared with the lines of our atmosphere. The atmosphere of this planet contains some of the gases or vapours present in our atmosphere, but it is not identical with it in constitution.

SATURN.—The observations of this planet are less certain because of the feebleness of its light. Some of the lines produced by its atmosphere appear to be identical with those seen in the spectrum of Jupiter.

MARS.—The lines characterizing the atmospheres of Jupiter and Saturn are not present in the spectrum of Mars. Groups of lines appear in the blue portion of the spectrum, and these by causing the predominance of the red rays, may be the cause of the red colour which distinguishes the light of this planet.

VENUS.—All the stronger lines of the solar spectrum were seen in the brilliant light of Venus, but no additional lines indicating an absorptive action of the planet's atmosphere.

In the case of most of the planets the solar light is probably reflected not from the planetary surface, but from clouds at some elevation above it; under such circumstances the light would not be subjected to the absorbent action of the lower and denser portions of the planet's atmosphere, which are precisely those of our atmosphere, which are most effectual in producing the so-called atmospheric lines.

Results of the Observations on the Fixed Stars.

Since these bodies are self-luminous, we may hope to gain by prismatic analysis more information of their nature, than it is possible to do of the planets which all shine by reflecting the sun's light.

What are the stars? Endeavour with the most powerful telescopes to approach them, still they assume no apparent size; they remain under the highest magnifying powers what they appear to the unaided eye, diskless, brilliant *points*.

Until quite recently, our knowledge of the stars might be summed up thus:—that they shine; that they are immensely distant; that the motions of some of them show them to be composed of matter endowed with a power of mutual attraction.

Photographs of drawings of the spectra of several stars were projected on a screen by means of the electric lamp. In these were seen the coincidences and relative positions of the dark lines of the stars with the bright lines of the elements which had been compared with them.

The results on the light of the stars, *Aldebaran* and *α Orionis* (*Betelgeux*) are given in the following table:—

Elements compared with ALDEBARAN.

COINCIDENT.

1.	Hydrogen	with lines C and F
2.	Sodium	„ double line D
3.	Magnesium	„ triple line *b*
4.	Calcium	„ four lines
5.	Iron	„ four lines and E
6.	Bismuth	„ four lines
7.	Tellurium	„ four lines
8.	Antimony	„ three lines
9.	Mercury	„ four lines

NOT COINCIDENT.

Nitrogen	three lines
Cobalt	two lines
Tin	five lines
Lead	two lines
Cadmium	three lines
Barium	two lines
Lithium	one line

70 lines measured.

Elements compared with α ORIONIS (BETELGEUX).

COINCIDENT.

1.	Sodium	with double line D
2.	Magnesium	„ triple line *b*
3.	Calcium	„ four lines
4.	Iron	„ three lines and E
5.	Bismuth	„ four lines
6.	Thallium ?	

NOT COINCIDENT.

Hydrogen	C and F
Nitrogen	three lines
Tin	five lines
Lead	two lines
Gold ?	
Cadmium	three lines
Silver	two lines
Mercury	four lines
Barium	two lines
Lithium	one line

80 lines measured.

The 70 or 80 lines measured represent some of the stronger only of the numerous lines which are seen in the spectra of these stars. Some of these are probably due to the vapours of other terrestrial elements which have not been compared with these stars. It would be assumption to suppose that the 65 so-called elements constitute in its entirety the primary material of the universe. Doubtless in the spectra of the stars the chemist is introduced to many new elements—would that it were possible for him to recognize and to isolate them!

It is a very suggestive fact that the lines of hydrogen corresponding with C and F of the solar spectrum are wanting in the spectra of α Orionis and β Pegasi, and in these two stars only, out of more than fifty stars examined,

β Pegasi contains	sodium, magnesium, perhaps barium.
Sirius „	sodium, magnesium, iron, hydrogen.
α Lyræ (Vega)	sodium magnesium, iron.
Pollux „	sodium, magnesium, iron.[*]

No stars sufficiently bright to give a spectrum have been observed to be without lines. Star differs from star alone in the grouping and arrangement of the numerous fine lines by which their spectra are crossed.

---

[*] The spectra of the following stars have also been examined:—Castor; ε, ζ, and η Ursæ Majoris; α and ε Pegasi; α, β, γ Andromedæ; Rigel, η Orionis; α Trianguli; γ and ε Cygni; α, β, γ, ε, and η Cassiopeiæ; γ Geminorum; β Canis Minoris; β Canis Majoris; Spica, γ, δ, and ε Virginis; α Aquilæ; Cor Caroli; β Aurigæ; Regulus, β, γ, δ, ε, ζ, and η Leonis.

The dark lines of absorption are strongest in the spectra of stars, the light of which is tinted with yellow or red. In *white* stars the lines, though equally numerous, are very fine and faint, with the exception of the lines of hydrogen which are relatively very strong. This suggests a peculiar condition of the investing atmospheres of white stars; a modification depending possibly upon their high temperature.

A comparison of the spectra of stars which differ in the colour of their light suggested the opinion that the colours of the stars have their origin in the chemical constitution of their atmospheres.

Since the source of the light of the stars is intensely heated solid (possibly liquid) matter, the light at the time of emission would be white alike in all the stars.

The colours of the spectrum in which the lines of absorption are most closely grouped, would be subdued in power relatively to the other colours, which would then predominate in the light of the star. This opinion is supported by the different arrangements of the lines in the spectra of the orange and blue components of the double star β Cygni.

From the additional knowledge which these spectrum observations give us, we are entitled to conclude that in plan of structure the stars closely resemble the sun. The source of their light is probably solid matter,* in a highly incandescent state. Around this photosphere, there exists an atmosphere of vapours of such of the elements of the stars as are volatile at their high temperature.

A community of matter appears to exist throughout the visible universe, for the stars contain many of the elements which exist in the sun and earth.

It is remarkable that the elements most widely diffused through the host of stars are some of those most closely connected with the living organisms of our globe, including hydrogen, sodium, magnesium, and iron. May it not be that, at least, the brighter stars are like our sun, the upholding and energizing centres of systems of worlds, adapted to be the abode of living beings?

Results of the Observations on the Nebulæ.

Besides the stars, the heavens are mottled over with feebly shining cloudlike patches and spots, often presenting strange and fantastic forms. Between 5000 and 6000 of these so-called *Nebulæ* are known. What is the nature of these strange objects? Dense swarms of suns melted into one mass by their enormous distance? Chaotic masses of the primordial material of the universe? The telescope alone ıld fail to give answers to these questions, and the analysis by the ım of objects so feebly luminous appeared hopeless.

---

* The phenomena of the solar spots appear to show that the solid matter of the sun's photosphere exists in a finely-divided state, and may be compared to the carbon in an ordinary gas-flame, or to the cloud of phosphoric acid when phosphorus is burnt in oxygen. The sun's surface consists of this matter separated into masses, which are neither uniform in size nor regular in form; they may be compared to clouds.

In August last, the speaker directed his telescope, armed with the ctrum apparatus, to a small but comparatively bright nebula, H. iv. His surprise was great to observe, that in place of a band coloured light, such as the spectrum of a star would appear, the ıt of this object remained concentrated in three bright, bluish-green s, separated by dark intervals. This order of spectrum showed the rce of the light was luminous *gas*. The brightest of the three lines a position in the spectrum about midway between *b* and F. More angible than this line, and separated from it by a dark interval, a ıter line occurs. The third and faintest line coincides with F, and h a line of hydrogen. The brightest line agrees in position with brightest of the lines of nitrogen. The line intermediate in re-ıgibility does not correspond with any of the elements compared h it.

NEBULÆ,

e Spectrum of which indicates Gaseity.		*The Spectrum of which is Continuous.*
H. iv.	Three bright lines.	92 M.
;		50 H. iv.
H. iv.		31 M. Great Neb. in Andromeda.
H. iv.		32 M.
. iv.		55 Andromeda.
great Neb. in Orion		26 H. iv.
H. iv.	A fourth, faint line also.	15 M.
ular Neb. in Lyra	The brightest line only.	2 M.
nb-bell Nebula		

A careful examination of different portions of the Dumbbell ıula, and of the great nebula in Orion, showed that both these ıulæ are uniform in constitution throughout, the light from one part ers from that of another in intensity alone.

The nebulæ 37 H. iv. and 73 H. iv., in addition to the bright lines, e a faint continuous spectrum ; this was proved to be due to the ıt of the *nucleus*.

These observations appear to authorize the following opinions of nature and structure of those of the nebulæ which give a spectrum bright lines.

1. The light from these nebulæ emanates from intensely heated tter existing in *the state of gas*. This conclusion is corroborated by great feebleness which distinguishes the light from the nebulæ. circular portion of the sun's disk subtending 1′ would give a light ıal to 780 full moons, yet many of the nebulæ, though they subtend ıuch larger angle, are invisible to the naked eye.[*] Upon the earth,

---

[*] See 'Outlines of Astronomy,' by Sir John F. W. Herschel, p. 616. 7th ion.

luminous gas emits a light which is very inferior in splendour to incandescent solid matter.

2. If these enormous masses of gas are luminous throughout, the light from the portions of gas beyond the surface visible to us, would be in a great measure extinguished by the absorption of the gas through which it would have to pass. These gaseous nebulæ would, therefore, present to us little more than a *luminous surface*. This consideration may assist in explaining the strange apparent forms of some of the nebulæ.

3. It is probable that two of the constituents of these nebulæ are the elements, hydrogen and nitrogen, unless the absence of the other lines of the spectrum of nitrogen indicates a form of matter more elementary than nitrogen. The third gaseous substance is at present unrecognized.

4. The uniformity and extreme simplicity of the spectra of all these nebulæ oppose the opinion that this gaseous matter represents the "nebulous fluid" suggested by Sir William Herschel, out of which stars are elaborated by a process of subsidence and condensation. In such a primordial fluid all the elements entering into the composition of the stars should be found. If these existed in these nebulæ, the spectra of their light would be as crowded with bright lines as the stellar spectra are with dark lines.

The supposition can scarcely be entertained that the three bright lines indicate a more primary and simple condition of matter; for then, if the process of elaboration into stars be now taking place, we should expect to find in some of the nebulæ, or in some parts of them, a more advanced state towards the formation of the separate elements of which we now know the stars to consist. Such an advance would be indicated by an increased number of bright lines. It is difficult to suppose that the excessively high temperature of the nebulæ keeps in check affinities by which, if unrestrained, the formation of the elements would take place; for in some of the nebulæ a nucleus exists, which from its continuous spectrum, its greater brightness, and apparent separation from the surrounding gas, we must regard as containing solid or liquid matter. At a temperature at which matter can become liquid or solid (though from peculiar conditions that temperature may be a very exalted one) we cannot suppose the formation of the chemical elements to be restrained by excessive heat.

5. A progressive formation of some character is suggested by the presence of more condensed portions, and in some nebulæ, of a nucleus. Nebulæ which give a continuous spectrum and yet show but little indication of resolvability, such as the great nebula in Andromeda, are not necessarily clusters of stars. They may be gaseous nebulæ, which by the loss of heat or the influence of other forces have become crowded with portions of matter in a more condensed and opaque condition.

6. If the observations of Lord Rosse, Professor Bond, and others are accepted in favour of the partial resolution of the annular nebula in Lyra, and the great nebula in Orion into discrete bright points,

se nebulæ must be regarded not as simple masses of gas, but as tems formed by the aggregation of gaseous masses. Is it possible t the permanence of general form of these nebulæ may be maintained the motions of these separate masses?

7. The opinion of the enormous distance of the nebulæ from our tem, since it has been founded upon the supposed extent of remotes at which stars of considerable brightness would cease to be sepaely visible in our telescopes, has no longer any foundation on which rest in reference at least to those of the nebulæ which give a specm of bright lines. It may be that some of these are not more dist from us than the brighter stars.

8. As far as the speaker's observations extend, they appear to be in our of the opinion that these nebulæ are gaseous systems possessing tructure and a purpose in relation to the universe altogether distinct m the great cosmical masses to which the sun and the fixed stars long. What is this special purpose? Many fascinating theories esent themselves in connection with the great problems of the conrvation of the energy of the universe, and of the source and mainance of solar and stellar heat. In the opinion of the speaker science ll be more advanced by the slow and laborious accumulation of facts, n by the easier feat of throwing off brilliant speculations.

[W. H.]

◆

WEEKLY EVENING MEETING,

Friday, May 26, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

Henry Bence Jones, M.A. M.D. F.R.S. Hon. Sec. R.I.

On the Chemical Circulation in the Body.

ll our knowledge usually passes through three stages as it advances perfection. First, a stage in which we think we know everything; en a stage in which we find we know nothing; and, finally, a stage which we rapidly obtain those clear and connected ideas in which l sound knowledge consists.

As regards the absorbent system of animals and the mode of action remedies, we have long been in the first or second stage, and this ening I hope to show you that there is reason for believing that in gard to these subjects we are about to enter on the third stage; for that, in addition to the circulation of the blood, there is the dawn of another or chemical circulation, dependent in part on the mechanical circulation, but carried on mostly by diffusion from the blood into the textures, and from the textures into the absorbents, which thus become necessary agents for performing those actions of oxidation and nutrition on which, in great part, animal life depends.

Mr. Huggins, in his discourse last week, showed us how the spectrum-analysis can determine the chemical composition and the physical constitution even of substances outside those circulating bodies that constitute our solar system. And as the nebulæ and fixed stars are beginning to be analyzed, so in the microcosm of our own bodies substances that are outside the circulating system of the blood can (by the peculiar light they give when burnt) be analyzed with such delicacy that elements can now be therein discovered which all other modes of analysis would entirely overlook.

The human body, in this discourse, may be regarded as consisting of four parts—a funnel, a circle, an envelope, and a drain.

The laws of diffusion modified by pressure determine the passage of all substances from the funnel into the circulation, from the circle into the envelope, and from the envelope or circle to the drains. To Mr. Graham we owe the investigation of the laws of diffusion of gases and liquids; and the division of substances into crystalloids and colloids. One or two experiments, and for them I am indebted to Mr. Ansell and to Mr. Graham, will make the meaning of these terms more clear to you. Inside and outside this porous cell there is at present atmospheric air. There is no passage of the outer air into the inside of the cell, nor of the inside air to the outside of the cell; but if hydrogen is put outside, being lighter than common air, it rapidly passes into the inside of the cell, whilst the heavier air inside more slowly passes out; and thus pressure is produced inside the cell, and the index shows how much pressure exists. So also with this india-rubber ball. When the gases inside and out differ, the lighter gas will pass rapidly in, and such an alteration of form will occur that a spring will be liberated and this bell will say that light gas has passed through the india-rubber ball. Mr. Ansell has invented this test for the explosive gas in coal mines, that it may ring its own alarm. In these beautiful illustrations of Mr. Anderson's the same excess of diffusion of the lighter over the heavier gas is shown more slowly. Originally over both jars the india-rubber was flat. But through the concave india-rubber the hydrogen has more rapidly passed out than the air has passed in; and through the convex rubber the hydrogen has more rapidly passed in than the atmospheric air has passed out.

So with these liquids, for which I am indebted to Mr. Graham. Here is a very diffusible crystalloid substance, acetate of rosaniline, or magenta; and in this other vessel there is a much less diffusible or colloid substance, cochineal. In half an hour the crystalloid will pass through the membrane, whilst the colloid will show no signs of passage.

Here is another semisolid contrast. In the one jar there is bichromate of potash in gelatine above, with pure gelatine below; and in the other cochineal in gelatine above and pure gelatine below: the bichromate diffuses whilst the cochineal is unmoved.

The same laws of diffusion modified by pressure determine in the body the passage of substances from the funnel into the circulation, from the circulation into the tissues or ducts, and from the tissues back through the absorbents to the circulation.

The circulation must not be regarded as the stem of a tree curled round on itself, but rather as a series of circles formed by each terminal branch-twig joining a terminal twig of the root. The enormous number of these terminal circles may be seen in any injected preparation of any part of the body. The whole substance seems to consist of these vessels alone. The walls of these vessels are of the finest membrane, through which diffusion takes place with the greatest rapidity into the tissues beyond the circulation. These tissues constitute the different organs of the body, nerves, muscles, glands, ligaments, bones, &c. Each particle of each nerve, muscle, or gland, is encompassed by blood-vessels on which its growth and its action depend; but there are some few spots in the body where blood-vessels would be dangerous to the function of the part. These parts may be called the fixed stars of our microcosm, they seem outside the circulating system which binds together the rest of the body.

The most numerous of these fixed stars are the cartilages of the joints; and at a far greater distance may be placed the most remarkable twin stars of our body, the crystalline lenses, which, without any circulation of their own, are separated from all circulation by an aqueous and glassy fluid, which themselves also have no circulation. The lenses then might well be thought to be altogether free from all the multitude of disturbing substances that enter through the funnel into the circulation of man. By this model, perhaps, you will best realize the distance of the lens from the circulation of the blood.

The lenses, the humours of the eye, and the cartilages of the joints, thus constitute the parts of the envelope most distant from the vessels, whilst the proper tissues of the various organs of the body constitute the parts of the envelope most immediately touching the circulation. The absorbent system and the ducts of glands constitute the drains by which substances that have passed out of the circle into the envelope are taken up into the circulation again or pass out of the body.

It has long been known that bile would diffuse into every texture; that madder would diffuse into the bones and into the fœtus, and urate of soda into the joints; carbazotic or picric acid into the skin; mercury into the gums; lead into the gums and muscles, and silver into the skin; and it has long been known that multitudes of substances would run through the funnel into the circulation and out through the envelope into some of the drains. Ether, asparagus, turpentine, and many other such substances require no mention here.

It occurred to me that both in animals and in plants* the spectrum-analysis ought to determine with certainty where diffusing substances go to; how long they are in going out of the circle into the envelope; how long they stay in the envelope, and how quickly they cease to appear in the drain; and with Dr. Dupré's help a long investigation into the rate of passage of crystalloids into and out of the textures of the body was undertaken. The delicacy of the spectrum-analysis may be seen in this table:—

Chlorate of soda . . .	$\frac{1}{180}$ millionth of a grain.
Carbonate of lithia . . .	$\frac{1}{3}$ "
Chloride of strontium . . .	1 "
Chloride of barium . . .	1 "
Chlorate of potass . . .	$\frac{1}{25}$ thousandth of a grain.
Chloride of lithium . . .	$\frac{1}{15}$ millionth of a grain.
Chloride of rubidium . . .	$\frac{1}{16}$ thousandth of a grain.
Chloride of cæsium . . .	$\frac{1}{150}$ "

Soda exists everywhere, and in everything we eat and drink, so there was no use in looking for soda in the circulation and envelope, for it was sure to be there.

Lithia exists in many vegetable and animal substances, according to the soil on which they grow or live. Here is a table of substances which we examined for lithia:—

In potatoes—seldom found
apples—sometimes
bread—traces
cabbage—distinctly
Rhine wines—always
French wines—distinctly
Sherry—distinctly
Port—distinctly

In tea—slight traces
coffee—slight traces
ale—slight traces
porter—slight traces
mutton—none
beef—none
milk—none.

It had already been found—

In sea water
kelp
spring water sometimes
ashes of wood grown in the Odenwald
Russian and other potashes
tobacco
vine leaves and grapes
ashes of the produce of the fields in the Palatinate
milk of animals eating the produce
ash of human blood and muscle
meteoric stones
all the drinking waters of London.

The spectrum of lithium is very characteristic and very perceptible, and some approximation to a quantitative determination may be arrived at by observing the amount of substance that requires to be burnt to obtain the reaction, and by the necessity, in some cases, for the removal of interfering substances previous to the combustion. Thus three degrees may readily be observed. The highest amount of lithia is present when each particle of the substance when introduced into the flame gives the lithia reaction; and a smaller amount of lithia is present when the whole of a lens or of an organ must be extracted with water to remove the lithia previous to the combustion; and the smallest trace is present when the substance has to be incinerated, the ash treated with sulphuric acid, the excess of acid driven off, the dry residue extracted with absolute alcohol, the alcohol evaporated and the dry residue tested. These three quantities may be designated as the slightest trace, a trace, and plenty.

---

* Cress sown on paper, when one inch high had the paper moistened with water containing a little chloride of lithium, in ten minutes and twelve minutes the lithium was detected in the leaves.

As soon as experiments on man and animals showed that the infinitesimal quantities taken in with the food were rarely to be perceived in the envelope, experiments were made to determine how quickly the lithium diffused from the funnel into the blood circulation, and from the circulation into the envelope, and whether it was to be found in those distant parts of the envelope where no circulation existed, and especially in the lens of the eye.

The following table gives the experiments made when lithia in small quantity was poured into the funnel on the rate of its passage not only into the circulation, but out of the circulation into the envelope of a guinea-pig.

The rate at which chloride of lithium passes into the textures through the stomach:

1½ grain	in 3 days	plenty found everywhere.	
3 "	15 minutes	everywhere	except in the lens.
"	30 "	"	"
"	30 "	"	traces in the lens.
"	30 "	"	outer part of the lens.
"	60 "	"	"
"	60 "	"	except in the lens.
"	in 2½ hours	"	and throughout the lens.
"	4 "	"	"
"	8 "	"	"
"	24 "	"	"
"	26 "	"	"
"	5¼ "	"	except in the lens.

It follows from these experiments that three grains of chloride of lithium given on an empty stomach, may diffuse into the cartilage of the hip-joint and the aqueous humour of the eye in a quarter of an hour. In very young and very small pigs, the same quantity of lithium may in 30 or 32 minutes be found in the lens of the eye, but in an old pig in this time the lithium will have got no farther than the humours of the eye. If the stomach was empty when the chloride of lithium was taken, in one hour the lithium may be very evident in the outer part of the lens and very faintly in the inner ;

but if the stomach be full of food the lithium does not in an hour reach the lens. Even in two hours and a half the lithium may be more marked in the outer than in the inner part of the lens. In four hours the lithium will be in every part of the lens, but it will still be more evident in the humours than in the lens. Even in eight hours the centre of the lens may show less than the outer part. The lithium will be found in as great quantity in the centre of the lens as in the outside after twenty-six hours.

When instead of being put in by the funnel, the lithia was injected into the skin: three grains of chloride of lithium in 24 minutes showed the lithium in the lens and in every texture; in 10 minutes slightly in the lens but plenty everywhere else; in 4 minutes no lithium was in the lens but plenty in the aqueous humour of the eye and in the bile; one and a half grain in five minutes showed no lithium in the lens but plenty in the aqueous humour and in the bile.

Having thus shown that lithium will pass everywhere into the textures in between 4 and 15 minutes, when injected into the circulation, and between 15 minutes and 26 hours when taken in by the funnel, some experiments were made to determine after how many days the lithium ceased to be detected in the envelope after it had been taken. Usually three pigs were taken: to one no lithium was given, the second was killed in a few hours after a dose of lithium, and the third was given the same dose and killed after many days.

The following Table shows the rate at which chloride of lithium passes out of the textures:—

2 grs. in 6 hours gave plenty everywhere.	In 6 days gave no trace in the alcoholic extract of the kidneys, livers, or lenses.
" — "	" " "
" — "	" 4 days gave none in the lens.
1 gr. in 5½ hours showed partly in the lens.	" 3 days gave faint traces in the lens.

It follows from these and other experiments that twice in six days and once in four days two grains of chloride of lithium, which in six hours gave lithium everywhere, in six days ceased to be detectable in the lens, and that even in three days the lithium is most probably diminishing in the lens.

Having thus gained a clear knowledge of the time it takes for a small quantity of lithia to pass in and out of the envelope of an animal, I proceeded, through the kindness of my friends Mr. Bowman and Mr. Critchett, to trace the passage of lithium into that part of the envelope which is most distant from the blood circulation in man. Lithia water is by no means an unpleasant drink, and a few minutes, or a few hours, or a few days before the operation for cataract, twenty grains of carbonate of lithia dissolved in water were taken.

No less than seven cataracts were previously examined with the eatest care, to determine whether lithia was usually absent, and in ly one instance was the very faintest trace of lithium detectable.

The following Table shows the rate of passage of carbonate of lithia into and out of cataracts—

20 grains of carbonate of lithia were taken

25	minutes		before the operation	—No trace of lithium was found in the cataract.
2½	hours		”	—Lithium in the watery extract of the cataract.
3½	”		”	—Lithium in each particle.
4	”		”	” ”
4¼	”		”	” ”
4½	”		”	” ”
5	”	(old man)	”	” ”
5	”		”	” ”
7	”		”	” ”
4	days	spontaneous soft cataract, 25 to 30	”	—Traces in alcoholic extract of ash.
7	”		”	—In alcoholic extract not the slightest trace of lithium.
7	”	5 hours	”	” ” ”
7	”		”	—Slightest trace in the alcoholic extract.”

It follows from these experiments, that in the human body twenty grains of carbonate of lithia poured into the funnel in two and a half hours will have partly passed into every particle of the envelope and beyond the blood circulation even into the most distant parts, and in three and a half hours it will be more distinctly present in each particle of the lens.

In four days it will still be distinctly present in each particle of the lens.

In five days it will have begun most clearly to pass out of the lens, and in seven days scarcely the smallest trace will be detectable there. The most striking experiment was in the case of a young girl with two soft cataracts. She took twenty grains of carbonate of lithia, and in seven hours one lens was removed, and the smallest particle of the lens showed the presence of lithium. The other cataract was not removed for seven days after the first operation; then not the slightest trace of lithium could be found in the lens.

A long series of experiments on the passage of lithium out by a drain, after it had been taken in by the funnel, showed nearly the same fact, namely, that after a dose of twenty grains, the lithium was not entirely thrown out of the body under six, seven, or eight days.

Thus, then, both in animals and man the same law obtains. A single dose of lithium in a few minutes passes through the circulation into all the ducts and into every particle of the body, and even into the parts most distant from the blood-circulation.* There it remains for a much longer time than it took to get into the textures, probably for three or four days, varying with the quantity taken; then it diminishes, and finally, in six, seven, or eight days, the whole quantity is thrown out of the body.

---

* When seven grains of carbonate of lithia were given eight hours before delivery, the lithium was detected in each particle of the umbilical cord.

In animals it is very difficult accurately to determine the time when a single dose is removed, for a portion passes out in the perspiration and gets into the hair, and the animal thence re-doses itself with the lithium which had already passed through the blood-circulation into the envelope and out by the skin drain, and this re-dosing may be continued over and over again, so that even for thirty or forty days, after a dose of three grains, some lithium may be detected in guinea pigs still passing out of the body.

Having thus traced the lithium in and out of the envelope the question of far greater importance remains—What does the lithium or other alkaline salt do whilst it is in the envelope? In other words, What is the action of alkalies in the system? What is the action of carbonated alkali at a temperature of 38 C. (100 Fahr.) when oxygen at the same time is present, on 1st, organic acids; 2nd, neutral hydrocarbons; 3rd, fatty matter; and 4th, albuminous substances.

The most remarkable instance of the action of alkali when organic acid and oxygen are in contact is in the decomposition of pyrogallic acid. In this vessel I have oxygen and pyrogallic acid in contact, and no action takes place and none would take place if alkali were not added; but immediately on the addition of potass, action begins, the pyrogallic acid is unable to keep its composition, and is burnt by the oxygen aided by the alkali. More stable acids of lower composition are produced, and these combine with the alkali and liberate carbonic acid. If carbonated instead of caustic alkali be used, the action is not nearly so rapid or complete as with caustic alkali.

The best example of the destruction of a neutral hydrocarbon by oxygen aided by alkali is in the reduction of oxide of copper by sugar. The metallic oxide furnishes the oxygen, the alkali assists the formation of acid in the sugar, and draws it out of the sugar destroying the neutral compound.

In fatty matters the alkali splits the fat into fatty acid and glycerine, and forms a soap with the acid. Oil of bitter almonds exposed to common oxygen or ozonized oxygen absorbed in two hours two cubic centimetres of oxygen; with carbonate of soda it absorbed in the same time ·2,75 CC. When mixed with an alcoholic solution of potash, and heated benzoic acid combines with the potash, and the whole contents of the tube solidify; the alkali causes the oxidation of the oil; and by extreme oxidation carbonic acid and water would be the final results.

The action of alkali and oxygen on albuminous substances at low or moderate temperatures, 100 Fahr., has not been yet studied. At high temperatures with alkali the entire decomposition of the substance with the production of carbonic acid and ammonia, and a multitude of less perfect products of oxidation have long been known; the same substances oxidized at a higher temperature without the presence of alkali give rise to fewer intermediate products, and to a greater amount of the ultimate products of oxidation, *viz.* water, carbonic acid and ammonia, out of which the albumen was originally formed.

M. Béchamp stated that by the oxidation of albumen by manganic acid urea was produced, but this proved to be benzoic acid; and probably kreatin, uric acid, urea and other products will not be obtained from albuminous substances until we follow the method of oxidation that occurs in the body, *viz* a temperature of 38 C. (100 Fahr.) a moderately strong solution of carbonate of soda and basic phosphate of soda, and the action of oxygen possibly in an ozonized state.

Von Gorup Basanez (Liebig's 'Annalen,' vol. cx. p. 86, and cxxv. p. 207) has traced the action of ozone at ordinary temperatures on a multitude of animal and vegetable substances, but of these my time allows me to mention only one or two striking examples.

Cane or grape sugar when in contact with ozone undergoes no change, but where grape sugar is exposed to ozone with potass, soda, or carbonate of soda, it is entirely oxidized, and carbonic and formic acids only result. When no alkali is present no action occurs. Cane sugar oxidizes with alkali and ozone much slower than grape sugar.

Olein is quite inactive when exposed to ozone, but with potass or carbonate of soda the olein is immediately oxidized. The olein is saponified and the glycerine is oxidized into acrolein and ultimately into carbonic, formic, and propionic acids. The oleic acid is much more slowly oxidized into formic and carbonic acid.

Hence the action of alkalies out of the body on the different classes of substances of which we are built up is sufficiently clear. The alkali disturbs the equilibrium of the elements in the organic body by its affinity for acids. Aided by oxygen and heat, more or less complex acids are formed from the neutral substances, and if the action of the alkali is sufficiently continued, carbonic acid water and ammonia alone remain.

The progress of therapeutics probably depends on the application of our knowledge of the action out of the body of different medicines on the different chemical constituents of the body, to the explanation of the action of the same substances on the components of the textures in the body.

I have shown you how alkali out of the body promotes oxidation. The chemist can have no doubt that the same action takes place in each particle of the textures to which the alkali is carried. Thus carbonate of lithia, soda, and potass, lime, magnesia, rubidium, cæsium, are indirectly oxidizing agents, increasing chemical action in the different substances of which the textures are composed, according to the amount of the different alkalies that can diffuse into the textures, according to the different properties of the substances capable of oxidation that happen to be in the textures, and according to the amount and active state of the oxygen present and the amount of heat that assists the action, and according to the facilities for the removal of the products of the combustion.

Chloride of rubidium and cæsium we have proved to follow the same law as chloride of lithium, in that these substances pass into the crystalline lens, and can be detected there; but the evidence is much less distinct than in the case of lithium, so that the rate of the passage of these substances in and out of the textures cannot so easily be determined. Twenty grains of chloride of rubidium, and the same quantity of chloride of cæsium were necessary to give traces of the spectrum reaction for these substances in the lenses of guinea pigs.

There can be no reasonable doubt that as alkalies pass in, so we shall prove that vegetable acids, if not stopped by the alkaline fluid that is contained in the circulation, will pass into every particle of the textures, and when there these acids must have exactly the reverse action to alkalines. By lessening the alkalescence of the tissues, vegetable acids must tend to stop the oxidizing process.

As starch, sugar, and alcohol may be looked upon as becoming in the body vegetable acids, there is here a vast field for research, for there can be no doubt that the sugar and alcohol of our food pass at least as quickly as alkalies into the vascular and non-vascular textures of our bodies.

How far mineral acids can penetrate into the textures cannot be determined, and it may well be doubted if they reach the textures at all, although, by rendering the blood less alkaline, they must indirectly render the diffusing fluid in the textures less alkaline also.

Alkaloids we hope to detect diffusing into the textures in the same way, if not at the same rate, as alkalies. How they act on the different components of the textures of the body, chemistry at present has not determined. The action of alkaloids on sugars, fatty matters, and albumen at first sight appears altogether unproved. There exists in the brain and nerves a substance discovered by Dr. Oscar Liebreich, and named by him protagon ($C_{116}H_{241}N_4O_{22}P$). It gives rise to neurine ($C_5H_{13}N$), glycerin-phosphoric acid and a fatty acid, when treated with alkali; and this substance, of which $\frac{1}{1000}$th forms a strong jelly with water, may be acted on by the alkaloid, and thus form a nerve substance, having very different physical and chemical properties from the protagon in its unaltered state.

Even the action of ammonia in the different tissues of the body is not yet made out. In the 'Phil. Trans.' part ii., 1851, p. 409, I have shown that in passing through the stomach into the blood, or when in the blood, ammonia is partially oxidized, and that the same oxidation happens when urea is taken, and probably when caffein and the alkaloids pass into the blood, but the action that occurs as soon as ammonia, urea, or alkaloids come into contact with the different substances in the different textures, and the rate at which these alkaloids are ultimately oxidized in the textures, has yet to be determined. The first effect of alkaloids is to increase chemical action; but the resulting chemical combinations that take place, and the alterations in the textures that are produced by ammonia, urea, and alkaloids are at present undetermined. Moreover, the alterations these substances occasion in the products of decomposition of the tissues, whilst being themselves finally decomposed and removed from the body, are still entirely unknown.

Judging from the action of alkalies, there can be little doubt that alkaloids in a few minutes diffuse into every texture, and act according to their powers on the different substances with which they come into contact. If our means of analysis were sufficient, they would be found probably for three or four or more days in the textures, generally much longer than the symptoms, which depend upon contrast, would lead us to expect.

Lastly, we have proved that some salts of the metals diffuse like chloride of lithium into every texture of the body. Three grains of sulphate of thallium we have followed in twenty-two hours into the crystalline lens, and into the cartilages, the nerves, the liver, and the kidneys. It may be doubted, perhaps, whether thallium is a metal; but the same fact we have also determined to be true of sulphate of silver by a very delicate galvanic arrangement.

In twelve days a grain and a quarter of sulphate of silver was given to a guinea pig. The ashes of the liver, kidney, and stomach showed silver fairly. The ash of the bile showed it rather less distinctly. The ash of the lenses showed only very slight traces of silver, but silver was there. The ash of the brain showed no silver.

And here again a vast field for inquiry is opened. What is the action of the metallic salts on the water, salts, hydrocarbons, fats, albuminous substances of which each tissue is built up? How do the metallic salts influence the oxidation and nutrition going on in the textures? The power of the salts of silver, lead, and mercury, &c., to form insoluble or soluble compounds with albumen out of the body seems to indicate the action of these substances on the albuminous matter in the body. A compound with the albumen may be formed which may check the action of the organ, or the metal may be reduced or form a sulphuret, as with silver salts, and may be deposited in the textures and there remain, rendering the organ useless, as with lead salts; or the metallic salt may set up a more active chemical change in the albuminous textures or substances with which it is brought into direct contact, and this chemical action may rise to that degree which is known as inflammation; and the salts of mercury may be taken as examples of substances possessing this action.

From this view of the rapid passage of crystalloid substances into the vascular and non-vascular textures of our bodies, there arises a feeling of surprise that under such constantly varying conditions, the different functions of the different parts can be carried on. There is, however, from these experiments, but little room to doubt that substances like water, alcohol, salt, and sugar, assisted by the mechanical circulation of the blood, can in a few minutes pass by diffusion into each particle of our textures; and if in them these substances must take part in the changes of matter and force that are proceeding there, according to the amount of substance that enters in, according to the chemical properties that the substance possesses, and according to the conditions and times during which the action proceeds.

Thus, this circulation of diffusion rises even to an equal if not to a greater importance than that other more mechanical circulation of the blood, which indeed, in two out of the four grand divisions of animals, is almost absent, and during the early weeks of our own fœtal life is entirely wanting; and in this chemical circulation we recognize a link between the lowest vegetable and the highest animal creation, since this diffusion is a necessary condition on which the chemical actions in both kingdoms of nature depend.

To sum up then, I have tried to show you that there are good grounds for believing that there exists within us, in addition to the mechanical or animal circulation of the blood, another, and a greater and a more strictly chemical circulation, closely resembling, if not identical with, that which obtains in the lower divisions of animals and in vegetables. A circulation in which substances continually pass from the outside of the body into the blood, and through the blood into the textures, and from the textures either into the ducts, by which they again pass back into the blood, or are thrown out of the body; or into the absorbents, by which they are again taken back into the blood, again to pass from it into the textures.

This chemical circulation leads directly to two most important inquiries:—First, whether substances that diffuse into this larger circulation act as they would do out of the body under somewhat similar circumstances upon the different substances with which they come into contact in the different textures; either promoting the formation of new compounds, or giving rise to decompositions in the substances that are present in the tissues.

And, secondly, whether the chemical force, which may have been latent for ages in the mineral and vegetable substances that can enter by our vegetable and mineral food and medicine into this larger circulation, may be so given out in the textures as to increase or diminish those actions of oxidation, motion, sensation, and growth, which almost, although not altogether, constitute that assemblage of correlated actions which we sum up in two words—Animal Life.

[H. B. J.]

WEEKLY EVENING MEETING,

Friday, June 2, 1865.

SIR HENRY HOLLAND, BART. M.D. D.C.L. F.R.S. President, in the Chair.

PROFESSOR HUXLEY, F.R.S.

On the Methods and Results of Ethnology.

THE lecturer commenced by defining the nature and the limits of Ethnology. Biology being the name applied to the science of life and living things, Zoology is that division of Biology which deals especially with animals; and Anthropology is that branch of Zoology which is specially concerned with man. Ethnology is the more special science which determines the distinctive characters of the persistent modifications of mankind, ascertains the distribution of these modifications in present and past times, and searches after the causes or conditions of existence, both of the modifications and of their distribution.

Turning to a map of the world, the lecturer next indicated and briefly characterized, in successive order, the more obvious and prominent persistent modifications of mankind, commencing with the *Australians.* With dark skins, these people conjoin wavy hair; their skulls are always long, but are sometimes high and sometimes depressed. The antero-posterior and transverse diameters of the brim of the pelvis in the male are more nearly equal than is usually the case in Europeans.

The *Negritos*, inhabiting the belt of islands which lie between Australia, Polynesia, and Micronesia, have dark skins and woolly hair, the skull sometimes inclining towards the Australian, and sometimes towards the Polynesian type.

The *Amphinesians* have the colour of the skin brown, in lighter or darker shades, and the hair is long, black, and straight or wavy; the skull varies in character. These people cover an enormous area, occupying almost all the other islands of the Pacific and Indian oceans.

The *Americans* have black straight hair; the skin exhibits various shades of reddish and yellowish brown, sometimes inclining to olive; the face is broad and scantily bea[illegible]d, the skull broad and high.

The *Esquimaux* have also [illegible]ght black hair and broad faces, with prominent cheek bones, [illegible] ls are r[illegible]kably long. They inhabit the Arctic shores [illegible] of [illegible] The rest of Eastern Asia is peopled [illegible] varying in colour from yellow to [illegible] quely set small eyes, [illegible], and usually is remarkably broad and rounded. The Lapps of North-eastern Europe have strongly-marked Mongolian characters, but the immense interval between the western limit of the Eastern Mongolians and Lapland is, in great measure, occupied by people with pale complexions, blue or light eyes, yellow or red hair, and prominent noses. These may be termed the *Xanthochroi.* They exhibit two very distinct forms of cranium—the Scandinavians having long heads, the Slavonians, Fins, South Germans, and Swiss, broad heads.

The *Melanochroi* have, like the Xanthochroi, prominent noses, pale skins, wavy hair, and abundant beards, but the hair is black or dark, and the eyes usually so. They inhabit Southern and Western Europe, Northern Africa, and Western Asia.

The *Negroes* with dark skin, woolly hair, projecting jaws, thick lips, and elongated skulls, people Central Africa; while the *Bushmen,* differing from the true negroes in their yellowish-brown colour, tufted hair, very small stature, and tendency to fatty and other integumentary outgrowths, inhabit the southern extremity of that continent.

The so-called "Drawidian" populations of Southern Hindostan lead us back physically as well as geographically towards the Australians, while the diminutive Mincopies of the Andaman Islands lie midway between the Negro and Negrito races.

The diversities of hair, complexion, and cranial characters observed among the modifications of mankind which have been enumerated, may be exhibited in the form of a tabular classification as follows:—

	LEIOTRICHI.			ULOTRICHI.	
	Dolichocephali.		Brachycephali.	Dolichocephali.	Brachycephali.
Leucous.					
		Xanthochroi.			
Leucomelanous.					
		Melanochroi.			
Xanthomelanous.					
	Esquimaux.		Mongolians.	Bushmen.	
		Amphinesians. Americans.			
Melanous.				Negroes.	Mincopies. (?)
	Australians.			Negritos.	

The "Leiotrichi" are the people with straight and wavy hair; the "Ulotrichi" are those with woolly hair; the "Dolichocephali" are the long-headed people; the "Brachycephali," the short-headed. "Leucous" signifies that the complexion is fair and the hair red or yellow: "Leucomelanous," that the skin is pale, but the hair dark; "Xanthomelanous," that the skin is yellow, brown, or olive, and the hair black; "Melanous," that the hair and skin are both very dark, or blackish.

As a rule, woolly-haired people are long headed; while, on the other hand, broad heads preponderate among the Leiotrichi, and only two of the stocks enumerated among them—the Esquimaux and the Australian—are exclusively long headed.

It is further worthy of remark that an ethnological chart projected in such a manner, that the Pacific Ocean occupies its centre, shows an Australian area occupied by a dark-skinned, smooth-haired people, separated by an incomplete inner zone of dark and woolly-haired Negroes and Negritos, from an outer zone of comparatively pale and smooth-haired men, occupying the Americas, Asia, North Africa, and Europe.

Having thus sketched the physical differences of the chief persistent modifications of mankind, the lecturer proceeded to consider the nature and the value of their other differences, linguistic and physiological. Great as is the value of the scientific study of language, philology cannot afford any basis for ethnological classification, unless it can be shown that the mixture or substitution of languages is always accompanied by a corresponding mixture or substitution of the blood of the people speaking those languages. If in any instance it can be proved that the language of a nation has changed fundamentally, while its blood has remained wholly or comparatively unmixed, or *vice versâ*, language ceases to be a test of ethnological affinity. Cases were adduced in support of each of those alternative propositions. With regard to the physiological differences of the known persistent modifications of mankind, there would appear to be good grounds for the belief that they are differently affected by the influences which give rise to diseases, but no sufficient evidence has yet been adduced in support of the doctrine held by some ethnologists, that any two of them exhibit the phenomena of hybridity.

Turning from the present to the past condition of mankind, attention was directed to the fact that our knowledge of most of the persistent modifications of mankind is very modern, and of later date than the fifteenth century; while, on the other hand, the oldest historical records give us no right to believe that the distribution of mankind was, at the time to which they refer, other than it is now.

Archæology proves the existence of dolichocephalic and brachycephalic people side by side, or in succession, in various parts of Europe, but affords no grounds for believing that they were different from stocks now existing in the same or adjacent localities; while, at present, palæontology does little more than reveal the existence of man in that quarter of the world before its physical condition had become that which it now is.

The lecturer finally proceeded to discuss the various hypotheses which have been offered to explain the facts of ethnology, pointing out that the strength of the Monogenists lies in their recognition of the anatomical unity of mankind, while the Polygenists have done no less service by bringing prominently forward the distinctness and permanence of the leading modifications of the human type. And in conclusion, he endeavoured to show in what way the application of Mr. Darwin's views to Ethnology reconciles the doctrine of anatomical unity with that of persistence of modification, and overcomes difficulties of distribution by taking into account the effects of geological change.

[T. H. H.]

GENERAL MONTHLY MEETING

Monday, June 5, 1865.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

Mrs. Elizabeth Beevor.
Samuel Canning, Esq.
Alfred Davis, Esq.
David Painter McEuen, Esq.
Joshua Metcalfe, Esq.
Joseph Moore, Esq.
Hamilton Noel Hoare, Esq.
Henry Arthur Hunt, Esq.
Henry Lee, Esq. F.R.C.S.

were *elected* Members of the Royal Institution.

William Henty, Esq.

was *admitted* a Member of the Royal Institution.

The Special Thanks of the Members were returned for the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151):—

Sir Henry Holland, Bart. Pres. R. I. (7th *annual donation*) £40 0 0

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

Accademia Pontificia de' Nuovi Lincei—Atti. Anno X. Sess. 1–7. fol. Roma, 1863-4.
Astronomical Society, Royal—Monthly Notices, 1864–5. No. 6. 8vo.
Chemical Society—Journal for April, 1865. 8vo.
Editors—Artizan for May, 1865. 4to.
  Athenæum for May, 1865. 4to.
  Chemical News for May, 1865. 4to.
  Engineer for May, 1865. fol.
  Horological Journal for May, 1865. 8vo.
  Journal of Gas-Lighting for May, 1865. 4to.
  Mechanics' Magazine for May, 1865. 8vo.
  Medical Circular for May, 1865. 8vo.
  Pharmaceutical Journal for May, 1865.
  Practical Mechanics' Journal for May, 1865. 4to.
Granville, A. B. M.D. F.R.S. M.R.I. (the Author)—The Great London Question of the Day; or, can Thames Sewage be converted into Gold? Part 1. Historical. 8vo. 1865.
Horticultural Society, Royal—Proceedings, 1865. No. 5. 8vo.

Kerr, Mrs. A. M.R.I.—Der Talisman James Richardson's erklärt von Ludolf Krehl. (M 7) 4to. 1865.
Longmans, Messrs. (the Publishers)—John Hullah: Lectures on the Third or Transition Period of Musical History, delivered at the Royal Institution of Great Britain. 8vo. 1865.
Macloughlin, D. M.D. M.R.I. (the Author)—The Question of Syphilis submitted to the Medical Profession. 8vo. 1865.
The Treatment of Cholera. 8vo. 1865.
Medical and Chirurgical Society, Royal—Proceedings. Vol. V. No. 1. 8vo. 1865.
Mickell, W. D. Esq.—N. Whitley: The Flint Implements of the Drift not Authentic. (K 92) 8vo. 1865.
Photographic Society—Journal, No. 157. 8vo. 1865.
Playfair, Lyon, C.B. LL.D. F.R.S.—On the Food of Man in relation to his Useful Work. (K 92) 8vo. 1865.
Royal Society of London—Proceedings, No. 74. 8vo. 1865.
Philosophical Transactions for 1864. Vol. CLIV. Parts 1 & 2. 4to. 1864-5.
Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Jan. und Feb., 1865. 4to.
Warington, George, Esq. F.C.S. (the Author)—The Phenomena of Radiation as exemplifying the Wisdom and Beneficence of God. (Actonian Prize Essay.) 16to. 1865.
Zoological Society of London—Transactions, Vol. V. Part 5. 4to. 1865.
Proceedings for 1864. 8vo.
Index, 1848-60. 8vo.

Wilson and Beadell, Messrs.—Photographic Portrait of Dr. Hofmann.

WEEKLY EVENING MEETING,

Friday, June 9, 1865.

THE LORD WENSLEYDALE, Vice-President, in the Chair.

EDWARD FRANKLAND, Esq. F.R.S.

PROFESSOR OF CHEMISTRY, R.I.

On Researches in Organic Chemistry in the Royal Institution.

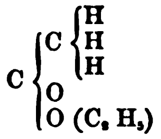
THE vast crowd of organic compounds with which modern research has made us acquainted, have been grouped into a comparatively small number of families, each containing substances closely allied in chemical character. Thus, amongst others, the following families or series of organic bodies are well known and sharply defined:—

1. The Marsh-gas family.
2. The Alcohols.
3. The Organic Ammonias.
4. The Fatty, or Acetic Series of Acids.
5. The Organic Oxalic Acids, or Lactic series.
6. The Acrylic series of Acids.

The speaker referred especially to the last three families as having been the subj[illegible] of the researches carried on in the laboratory of the

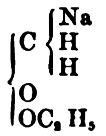
Royal Institution during the past year by his friend Mr. Duppa and himself. Two of these families had already received the careful study of many chemists; the acetic having been especially illustrated by the classic researches of Kolbe and Gerhardt, whilst the lactic family had quite recently had the advantage of the equally remarkable investigations of Wurtz and Kolbe. Nevertheless, there seemed to be still some points of great interest regarding the arrangement of the atoms of these acids,—their atomic architecture, so to speak,—which had not yet received elucidation; whilst the acrylic family had hitherto enjoyed comparatively but little attention from chemists.

It had been proved by Kolbe and the speaker, nearly twenty years ago, that methyl (CH_3) is a constituent of acetic acid, and more recently that acetic acid and acetic ether are constructed upon the carbonic acid or tetratomic carbon type, the formula of acetic ether being—



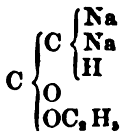
$$C\left\{\begin{array}{l} C\left\{\begin{array}{l}H\\H\\H\end{array}\right. \\ O \\ O\,(C_2H_5)\end{array}\right.$$

From this formula it was seen, that the radical methyl in acetic ether contained three single atoms of hydrogen combined with a tetratomic atom of carbon; and the speaker and his friend proposed to themselves the question: Can this hydrogen be replaced atom for atom by the alcohol radicals methyl, ethyl, &c.? In endeavouring to solve this problem, they availed themselves of that class of chemical reactions in which an electro-positive atom is expelled from a compound by a more electro-positive atom. Acetic ether was submitted to the action of sodium, by which two compounds of the following composition were obtained:—



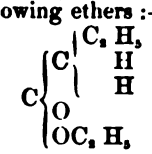
$$\left\{\begin{array}{l} C\left\{\begin{array}{l}Na\\H\\H\end{array}\right. \\ O \\ OC_2H_5\end{array}\right.$$

and



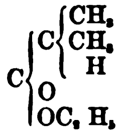
$$C\left\{\begin{array}{l} C\left\{\begin{array}{l}Na\\Na\\H\end{array}\right. \\ O \\ OC_2H_5\end{array}\right.$$

These compounds, when brought into contact with the iodides of methyl, ethyl, &c., yielded ethers, exhibiting the substitution which it was sought to obtain. In this way there had been produced the following ethers:—



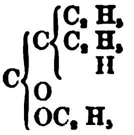
$$C\left\{\begin{array}{l} C\left\{\begin{array}{l}C_2H_5\\H\\H\end{array}\right. \\ O \\ OC_2H_5\end{array}\right.$$

Ethacetic or Butyric Ether.



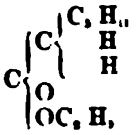
$$C\left\{\begin{array}{l} C\left\{\begin{array}{l}CH_3\\CH_3\\H\end{array}\right. \\ O \\ OC_2H_5\end{array}\right.$$

Dimethacetic Ether.



$$C\left\{\begin{array}{l} C\left\{\begin{array}{l}C_2H_5\\C_2H_5\\H\end{array}\right. \\ O \\ OC_2H_5\end{array}\right.$$

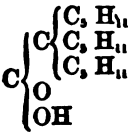
Diethacetic Ether.



$$C\left\{\begin{array}{l} C\left\{\begin{array}{l}C_5H_{11}\\H\\H\end{array}\right. \\ O \\ OC_2H_5\end{array}\right.$$

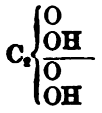
Œnanthylic Ether.

These ethers readily yielded their respective acids by contact with alcoholic solution of potash, and thus the homologous series of fatty acids could be ascended step by step, starting from acetic acid, and terminating with an acid of the composition of margaric acid, containing three atoms of amyl in the place of the three atoms of hydrogen in the methyl of acetic ether.



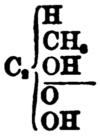
$$C\left\{\begin{array}{l} C\left\{\begin{array}{l} C_5H_{11} \\ C_5H_{11} \\ C_5H_{11} \end{array}\right. \\ O \\ OH \end{array}\right.$$

A similar inquiry had been instituted with regard to the family of acids of which lactic acid is a member, and it had been proved that this series of acids are derived from oxalic acid by the substitution of one atom of diatomic oxygen, in the latter by two of hydrogen, methyl, ethyl, &c. The following, amongst numerous other examples, were referred to in illustration of the relations of the primary to the derived acids :—



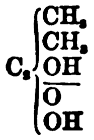
$$C_2\left\{\begin{array}{l} O \\ OH \\ \hline O \\ OH \end{array}\right.$$

Oxalic Acid.



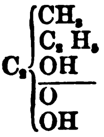
$$C_2\left\{\begin{array}{l} H \\ CH_3 \\ OH \\ \hline O \\ OH \end{array}\right.$$

Lactic Acid.



$$C_2\left\{\begin{array}{l} CH_3 \\ CH_3 \\ OH \\ \hline O \\ OH \end{array}\right.$$

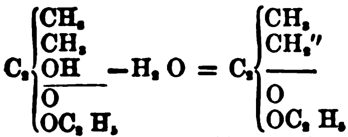
Dimethoxalic Acid.



$$C_2\left\{\begin{array}{l} CH_3 \\ C_2H_5 \\ OH \\ \hline O \\ OH \end{array}\right.$$

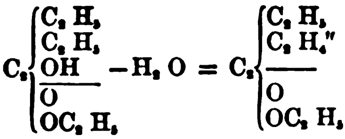
Ethylomethoxalic Acid.

From the lactic family of acids access had also been gained to the acrylic family, for it had been found that the abstraction of water from the ether of an acid of the lactic family converted it into the ether of an acid of the acrylic family, thus :—



$$C_2\left\{\begin{array}{l} CH_3 \\ CH_3 \\ OH \\ \hline O \\ OC_2H_5 \end{array}\right. - H_2O = C_2\left\{\begin{array}{l} CH_3 \\ CH_2'' \\ \hline O \\ OC_2H_5 \end{array}\right.$$

Dimethoxalic Ether. Methacrylic Ether.

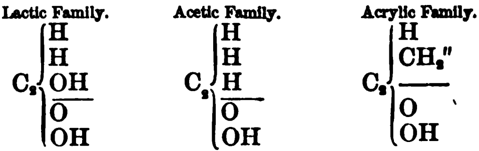


$$C_2\left\{\begin{array}{l} C_2H_5 \\ C_2H_5 \\ OH \\ \hline O \\ OC_2H_5 \end{array}\right. - H_2O = C_2\left\{\begin{array}{l} C_2H_5 \\ C_2H_4'' \\ \hline O \\ OC_2H_5 \end{array}\right.$$

Diethoxalic Ether. Ethylcrotonic Ether.

The production of these acids was not merely interesting on account of the addition of new members to the acrylic family, but their derivation from the synthesized acids of the lactic family afforded the most convincing proof of the style of architecture in which they were built up.

The investigation of the three families of acids had conclusively established between them the very simple relations exhibited in the three following formulæ:—



Lactic Family. Acetic Family. Acrylic Family.

$$C_2\left\{\begin{array}{l}H\\H\\\underline{OH}\\O\\OH\end{array}\right.\qquad C_2\left\{\begin{array}{l}H\\H\\\underline{H}\\O\\OH\end{array}\right.\qquad C_2\left\{\begin{array}{l}H\\CH_2''\\\text{——}\\O\\OH\end{array}\right.$$

Glycollic Acid. Acetic Acid. Acrylic Acid.

The speaker concluded as follows:—The day has almost gone by when the experimenter was asked the use of such investigations as these; nevertheless, it may fairly be demanded, Whither do such researches tend? What is their object? The sole object that we have had in view in these investigations has been the discovery of the laws according to which organic compounds are moulded,—those compounds, the transformation of which from one state of combination to another constitutes an essential part of the phenomena we call *life*. There is no royal road to this kind of knowledge. It is only by thus patiently and laboriously examining every part of the subject, that the combined efforts of the physicist, the physiologist, and the chemist will one day be able to solve the organic problems which at the present moment appear so unapproachable. The work before us requires a vast amount of experiment and thought. Would that more labourers were engaged in it! How many men of leisure and ability are almost compelled to pass through life with no higher object than their own amusement. Why cannot our schools and universities furnish the next generation of such men, with the scientific knowledge necessary to enable them to take part in the glorious work of investigating Nature?

[E. F.]

GENERAL MONTHLY MEETING,

Monday, July 3, 1865.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

Samuel Spalding, Esq.

was *elected* a Member of the Royal Institution.

The Managers reported, That in pursuance of the Deed of Endowment, they had appointed THOMAS HENRY HUXLEY, Esq. F.R.S. to be Fullerian Professor of Physiology.

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

Asiatic Society of Bengal—Journal, No 123. 8vo. 1864.
Astronomical Society, Royal—Monthly Notices, 1864-5. No. 7. 8vo.
Chemical Society—Journal for May, 1865. 8vo.
Editors—American Journal of Science, May, 1865. 8vo.
  Artizan for June, 1865. 4to.
  Athenæum for June, 1865. 4to.
  Chemical News for June, 1865. 4to.
  Engineer for June, 1865. fol.
  Horological Journal for June, 1865. 8vo.
  Journal of Gas-Lighting for June, 1865. 4to.
  Mechanics' Magazine for June, 1865. 8vo.
  Medical Circular for June, 1865. 8vo.
  Pharmaceutical Journal for June, 1865.
  Practical Mechanics' Journal for June, 1865. 4to.
Herschel, Alex. Esq. (*the Author*)—On the Secular Change of Temperature of the Air at Greenwich. (Brit. Met. Soc. Proceedings.) 8vo. 1865.
Horticultural Society, Royal—Proceedings, 1865. No. 6. 8vo.
Institution of Civil Engineers—Minutes of Proceedings, Vol. XXI. 8vo. 1862.
  Index to Vols. I.-XX. 8vo. 1865.
Linnean Society—Journal and Proceedings, Nos. 33 & 34. 8vo. 1865.
Liverpool Literary and Philosophical Society—Proceedings, No. 18. 8vo. 1864.
London Library Committee—Catalogue. 3rd edition. 8vo. 1865.
Lunacy Commissioners—Nineteenth Report. 8vo. 1865.
Manning, Frederick, Esq. M.R.I.—Astra Castra: Experiments and Adventures in the Atmosphere. By Hatton Turner. 4to. 1865.
Mechanical Engineers' Institution, Birmingham—Proceedings, August, 1864. 8vo.
Meteorological Society, British—Proceedings, No. 19. 8vo. 1864.
Oliveira, Benjamin, Esq. F.R.S. M.R.I. (*the Author*)—Visit to the Spanish Camp in Morocco. (K 92) 8vo. 1865.
  Letters on Teneriffe and Madeira. (K 92) 8vo. 1865.
Photographic Society—Journal, No. 158. 8vo. 1865.
Royal Society of London—Proceedings, No. 75. 8vo. 1865.
Royal Academy of Sciences, Madrid—Memorias: Tomo VI. Partes 1 & 2. 4to. 1864-5.
  Resumen de las Actas, 1862-3. 4to. 1864.
  Libros del Saber de Astronomia del Rey Alfonso X. de Castilla. Tomo III. 4to. 1864.
Salviati, Dr. A. (*the Author*)—On Mosaics. (L 14) 8vo. 1865.
Scharf, George, Esq. F.S.A. (*the Author*)—Catalogue of the Pictures belonging to the Society of Antiquaries, London. 8vo. 1865.
Statistical Society of London—Journal. Vol. XXVII. Part 4. 8vo. 1864.
Tyndall, Professor, LL.D. F.R.S. (*the Author*)—Heat considered as a Mode of Motion. 2nd edition. 12mo. 1865.
  On Radiation (the Rede Lecture). 12mo. 1865.
United Service Institution, Royal—Journal, Vol. VIII. Appendix. 8vo. 1865.
Wilson, Thomas, Esq. M.R.I. (*the Author*)—Partnership "en Commandite;" or, Partnership with Limited Liabilities. 8vo. 1848.
  The Railway System, and its Pioneer Thomas Gray. (K 92) 8vo. 1860.

His Eminence Cardinal Wiseman,

On Shakespeare.

["In the autumn of last year a communication was made to his Eminence the late Cardinal Wiseman, by H. Bence Jones, Esq., M.D., as Secretary of the Royal Institution of Great Britain, requesting him to deliver a lecture before that Society. The Cardinal, with the prompt kindness usual to him, at once assented. The Shakespeare Tercentenary seemed to prescribe the subject, which his Eminence therefore selected. The preparation of this lecture" (which was to have been delivered on the 27th of January last) "was his last intellectual exertion, and it overtaxed his failing strength." He died on the 15th of February. His literary executors have published "only a fragment of a whole which was never completed except in the author's mind." "The day before his illness, the Cardinal said to his amanuensis, the Rev. Dr. Clifford, 'I shall have no more real work, for I have every sentence that I am going to dictate already in my mind; it is only a question of time now. I know word for word what I shall say.'"*

The following abbreviation of the intended lecture is printed with the consent of the Cardinal's literary executors.]

THERE have been some men in the world's history—and they are necessarily few—who by their deaths have deprived mankind of the power to do justice to their merits, in those particular spheres of excellence in which they had been pre-eminent. When the "immortal" Raphael for the last time laid down his palette, still moist with the brilliant colours which he had spread upon his unfinished masterpiece, destined to be exposed to admiration above his bier, he left none behind him who could worthily depict and transmit to us his beautiful lineaments: so that posterity has had to seek in his own paintings, among the guards at a sepulchre, or among the youthful disciples in an ancient school, some figure which may be considered as representing himself. * * * *

No less can it be said that when the pen dropped from Shakespeare's hand, when his last mortal illness mastered the strength of even his genius, the world was left powerless to describe in writing his noble and unrivalled characteristics. Hence we turn back upon himself, and endeavour to draw from his own works the only true records of his genius and his mind. We apply to him phrases which he has uttered of others; we believe that he must have involuntarily described himself, when he says,

"Take him all in all,
We shall not look upon his like again;"

---

* From the Preface to 'William Shakespeare. By his Eminence Cardinal Wiseman.' 8vo. Hurst & Blackett, 1865.

or that he must even consciously have given a reflection of himself when he so richly represents to us "the poet's eye in a fine phrenzy rolling."—*Midsummer Night's Dream*, act v. scene 1. * * *

The almost total absence of all external information, this drying-up of the ordinary channels of personal history, forces us to seek for the character and the very life of Shakespeare in his own works. But how difficult, in analysing the complex constitution of such a man's principles, motives, passions, and affections, to discriminate between what he has drawn from himself, and what he has created by the force of his imagination. Dealing habitually with fictions, sometimes in their noblest, sometimes in their vilest forms—here gross and even savage, there refined and sometimes ethereal, how shall we discover what portions of them were copied from the glass which he held before himself, what from the magic mirrors across which flitted illusive or fanciful imagery? The work seems hopeless. * * * *

This difficulty of appreciating, and still more of delineating, the character of our great poet, makes him, without perhaps an exception, the most difficult literary theme in English letters. How to reduce the subject to a lecture seems indeed a literal paradox. But when to this difficulty is added that of an impossible compression into narrow limits of the widest and vastest compass ever embraced by any one man's genius, it must appear an excess of rashness in anyone to presume that he can do justice to the subject on which I am addressing you. * *

In truth the undertaking required some courage; and to retire before its difficulties might be stigmatised as a dastardly timidity. It is a work of courage at any time and in any place to undertake a lecture upon Shakespeare, more in fact than to venture on the delivery of a series. * * * *

When everybody else is silent, it may be very naturally asked have I a single claim to put forward upon your attention and indulgence? I think I may have *one;* though I fear that when I mention it, it may be considered either a paradox or a refutation of my pretensions. My claim, then, to be heard and borne with is this—that I have never in my life seen Shakespeare acted; I have never heard his eloquent speeches declaimed by gifted performers; I have not listened to his noble poetry as uttered by the kings or queens of tragedy; I have not witnessed his grand, richly-concerted scenes endowed with life by the graceful gestures, the classical attitudes, the contrasting emotions, and the pointed emphasis of those who in modern times may be considered to have even added to that which his genius produced; I know nothing of the original and striking readings or renderings of particular passages by masters of mimic art; I know him only on his flat page, as he is represented in immovable, featureless, unemotional type. * * * *

After having said thus much of my own probably unenvied position, I think I shall not be wrong in assuming that none of Shakespeare's enthusiastic admirers, one of whom I profess myself to be, and that few of my audience are in this exceptional position. They will probably consider this a disadvantage on my side; and to some extent I must acknowledge it—for Shakespeare wrote to be acted, and not to be read.

But on the other hand is it not something to have approached this wonderful man, and to have communed with him in silence and in solitude, face to face, alone with him alone; to have read and studied and meditated on him in early youth, without gloss or commentary, or preface or glossary? For such was my good or evil fortune; not during the still hours of night, but during that stiller portion of an Italian afternoon, when silence is deeper than in the night, under a bright and sultry sun, when all are at rest, all around you hushed to the very footsteps in a well-peopled house, except the unquelled murmuring of a fountain beneath orange trees, which mingled thus the most delicate of fragrance with the most soothing of sounds, both stealing together through the half-closed windows of wide and lofty corridors. Is there not more of that reverence and that relish which constitute the classical taste to be derived from the concentration of thought and feelings which the perusal of the simple unmarred and unoverlaid text procures; when you can ponder on a verse, can linger over a word, can repeat mentally and even orally with your own deliberation and your own emphasis, whenever dignity, beauty, or wisdom invite you to pause, or compel you to ruminate? * * * *

You will easily understand, from this long and almost apologetic preamble, in the first place, that I take it for granted that I am addressing an audience which is not assembled to receive elementary or new information concerning England's greatest poet. On the contrary, I believe myself to stand before many who are able to judge, rather than merely accept, my opinions, and in the presence of an assembly exclusively composed of his admirers, thoroughly conversant with his works. * * * *

Among our native writers no one questions that Shakespeare is supremely pre-eminent, and most of us will probably assign him as lofty a position in the whole range of modern European literature. Perhaps no other nation possesses among its writers any one name to which there is no rival claim, nor even an approximation of equality, to make a balance against it. * * * *

Shakespeare has established his claim to the noblest position in English literature on a wider and more solid basis than the mere composition of skilful plays could deserve. As the great master of our language, as almost its regenerator, quite its refiner—as the author whose use of a word stamps it with the mark of purest English coinage—whose employment of a phrase makes it household and proverbial—whose sententious sayings, flowing without effort from his mind, seem almost sacred, and are quoted as axioms or maxims indisputable—as the orator whose speeches, not only apt, but, natural to the lips from which they issue, are more eloquent than the discourses of senators or finished public speakers—as the poet whose notes are richer, more wondrously varied than those of the greatest professed bards—as the writer who has run through the most varied ways and to the greatest xtent through every department of literature and learning, through he history of many nations, their domestic manners, their characteristics, nd even their personal distinctives, and who seems to have visited very part of nature, to have intuitively studied the heavens and the arth—as the man in fine, who has shown himself supreme in so nany things, superiority in any one of which gains reputation in life nd glory after death, he is pre-eminent above all, and beyond the each of envy or jealousy. * * * *

The question, however, may be raised—Is he so securely placed ipon his pedestal that a rival may not one day thrust him from it?—s he so secure upon his throne that a rebel may not usurp it? To hese interrogations I answer unhesitatingly—Yes.

In the first place, there have only been two poets in the world efore Shakespeare who have attained the same position with him. Each came at the moment which closed the volume of the period past, nd opened that of a new epoch. Of what preceded Homer we can now but little; the songs by bards or rhapsodists had, no doubt, receded him, and prepared the way for the first and greatest epic. This, it is acknowledged, has never been surpassed; it became the tandard of language, the steadfast rule of versification, and the model f poetical composition. His supremacy, once attained, was shaken y no competition; it was as well assured after a hundred years as t has been by thousands. Dante again stood between the remnants f the old Roman civilization and the construction of a new and hristian system of arts and letters. He, too, consolidated the loating fragments of an indefinite language, and with them built nd thence himself fitted and adorned that stately vessel which ears him through all the regions of life and of death, of glory, of rial, and of perdition. * * * *

The two centuries and more which have elapsed since Shakespeare's leath have as completely confirmed him in his legitimate command as he same period did his two only real predecessors. No one can ossibly either be placed in a similar position or come up to his great ualities, except at the expense of the destruction of our present ivilization, the annihilation of its past traditions, the resolution of our anguage into jargon, and its regeneration, by a new birth, into somehing "more rich and strange" than the powerful idiom which so plendidly combines the Saxon and the Norman elements. Should uch a devastation and reconstruction take place, whether they come rom New Zealand or from Siberia, then there may spring up the poet f that time and condition who may be the fourth in that great series f unrivalled bards, but will no more interfere with his predecessor's ights than Dante or Shakespeare does with those of Homer. * * *

But still more may we say that, in all such positions as that which ve have assigned to Shakespeare, there has always been a culminating oint to which succeeds decline—if not downfall. It is so in art. Immediately after the death of Raphael, and the dispersion of his chool, art took a downward direction, and has never risen again to he same height. And while he marks the highest elevation ever reached in the arts of Europe, a similar observation will apply to their particular schools. Leonardo and Luini in Lombardy; the Carracci in Bologna; Fra Angelico in Umbria; Garofalo in Ferrara, not only take the place of chiefs in their respective districts, but mark the period from which degeneracy has to date. And so surely is it in our case, whatever may have been the course of literature which led up to Shakespeare, without pronouncing judgment on Spenser, or "rare Ben Jonson," it is certain that after him, although England has possessed great poets, there stands not one forward among them as Shakespeare's competitor. Milton, and Dryden, and Addison, and Rowe have given us specimens of high dramatic writing of no mean quality; others as well, and even these have written much and nobly, in lofty as in familiar verse; yet not one has the public judgment of the nation placed on a level with him. The intermediate space from them to our own times has left only the traces of a weak and enervated school. It would be unbecoming to speak disparagingly of the poets of the present age; but no one, I believe, has ventured to consider them as superior to the noble spirits of our Augustan age. The easy descent from the loftiest eminence is not easily reclimbed.

Surely, then, we may consider Shakespeare, as an ancient mythologist would have done, as "enskied" among "the invulnerable clouds," where no shaft, even of envy, can assail him. From this elevation we may safely predict that he never can be plucked. * * * *

To what does Shakespeare owe this supremacy, or whence flow all the extraordinary qualities which we attribute to him? You are all prepared with the answer in one single word—his GENIUS.

The genius of Shakespeare is our familiar thought and ready expression when we study him, and when we characterise him. Nevertheless, simple and intelligible as is the word, it is extremely difficult to analyse or to define it. Yet everything that is great and beautiful in his writings seems to require an explanation of the cause to which it owes its origin.

One great characteristic of genius easily and universally admitted is, that it is a gift, and not an acquisition. It belongs inherently to the person possessing it; it cannot be transmitted by heritage; it cannot be infused by parental affection; it cannot be bestowed by earliest care; neither can it be communicated by the most finished culture or the most studied education. It must be congenital, or rather inborn to its possessor. It is as much a living, a natural power, as is reason to every man. As surely as the very first germ of the plant contains in itself the faculty of one day evolving from itself leaves, flowers, and fruit, so does genius hold, however hidden, however unseen, the power to open, to bring forth, and to mature what other men cannot do, but what to it is instinctive and almost spontaneous. It may begin to manifest itself with the very dawn of reason: it may remain asleep for years, till a spark, perhaps accidentally, kindles up into a sudden and irrepressible splendour, that unseen intellectual fuel which has been almost unknown to its unambitious owner. * * * *

We connect in our minds with genius the ideas of flashing splendour and eccentric movement. It is an intellectual meteor, the laws of which cannot be defined or reduced to any given theory. We regard it with a certain awe, and leave it to soar or to droop, to shine or disappear, to dash irregularly first in one direction and then in another; no one dare curb it or direct it; but all feel sure that its course, however inexplicable, is subject to higher and controlling rule. But in order to define more closely what we in reality understand by genius, it may be well to consider its action in divided and more restricted spheres of activity. For although we habitually attribute this singular quality to many, and often but on light grounds, it is seldom that we do so seriously and deliberately without some qualifying epithet. We speak of a military genius, of a mechanical genius, of a poetical genius, of a musical genius, or of an artistic genius. All these expressions contain a restrictive clause. We do not understand when we use them that the person to whom they were attributed possessed any power beyond the limits of a particular sphere. We do not mean by the use of the word genius that the soldier knew anything of poetry, or the printer of mechanism. We understand that each in his own profession or stage of excellence possessed a complete elevation over the bulk of those who followed the same pursuits; a superiority so visible, so acknowledged, and so clearly individual, that no one else considered it inferiority, still less felt shame, at not being able to rise to the same level. They gather round them acknowledged disciples and admirers, who rather glory to have been guided by their teaching, and formed on their example.

And in what consisted that complete though limited excellence? If I might venture to express a judgment, I would say that genius in these different courses of science or art may be defined a natural sympathy with all that relates to each of them, with the power of giving full and certain execution to the mental conception.

Stephenson, from the labour of the mine, creating that system of mechanical motion, which may be said to have subdued the world, and bound the earth in iron links; Mozart, giving concerts at the age of seven, that astonished grey-headed musicians; Raphael, before the ordinary age of finished pupilage, master of every known detail in art of oil or fresco, drawing, expression, and grand composition; Giotto, caught in the field as a young shepherd by Cimabue, drawing his sheep upon a stone, and soon becoming the master of modern art. * * * *

Raphael was before the world a painter, but he could scarcely have been so without embracing every other department of art. Before the science of perspective was matured or popularly known, when, in consequence, defects are to be found in the disposition of figures, and in the adjustment of aerial distances, his architecture shows an instinctive familiarity with its rules and proportions; a proof that he possessed an architectural eye. And consequently the one statue which he is supposed to have carved, and the one palace which he is said to have built, show how easily he could have undertaken and executed beautiful works in either of those two class of art. * * * *

It is evident, however, that while a genius has its point of concentration, every remove from this, though wider, will be fainter and less complete. We may describe it as Shakespeare himself describes glory, and say:

> "*Genius* is like a circle in the water,
> Which never ceaseth to enlarge itself,
> Till, by broad spreading, it disperse to naught."
> *Henry VI.*, act. i. scene 3.

* * * * * *

All that I have been saying is applicable in the most complete and marvellous way to Shakespeare's genius. His sympathies are universal, perfect in their own immediate use, infinitely varied, and strikingly beautiful, when they reach remoter objects. * * * *

The centre-point of his sympathies is clearly his dramatic art. From this they expand, for many degrees, with scarce perceptible diminution, till they lose themselves in far distant, and, to him, unexplored space. This nucleus of his genius has certainly never been equalled before or since. Its essence consists in what is the very soul of the dramatic idea, the power to throw himself into the situation, the circumstances, the nature, the acquired habits, the feelings, true or fictitious, of every character which he introduces. This forms, in fact, the most perfect of sympathies. We do not, of course, use the word in that more usual sense of harmony of affection, or consent of feeling. Shakespeare has sympathy as complete for Shylock or Iago, as he has for Arthur or King Lear. For a time he lives in the astute villain as in the innocent child; he works his entire power of thought into intricacies of the traitor's brain; he makes his heart beat in concord with the usurer's sanguinary spite, and then, like some beautiful creature in the animal world, draws himself out of the hateful evil, and is himself again; and able, even, often to hold his own noble and gentle qualities as a mirror, or exhibit the loftiest, the most generous, and amiable examples of our nature. And this is all done without study, and apparently without effort. His infinitely varied characters come naturally into their places, never for a moment lose their proprieties, their personality, and the exact flexibility which results from the necessary combination in every man of many qualities. From the beginning to the end each one is the same, yet reflecting in himself the lights and shadows which flit around him.

This extraordinary versatility stands in striking contrast with the dramatic productions of other countries. The Greek tragedian is Greek throughout— his subjects, his mythology, his sentences, play wonderfully indeed, but yet restrictedly, within a given sphere. And Rome is but the imitator in all its literature of its great mistress and model.

> "Graiis eloquium, Graiis dedit ore rotundo,
> Musa loqui."

Even through the French school, with the strict adhesion to the ancient rule of the unities, seems to have descended the partiality for what may be called the chastely classical subjects. Not so with Shakespeare.

Who, a stranger might ask, is the man, and where was he born, and where did he live, that not only his acts and scenes are placed in any age, or in any land, but that he can fill his stage with the very living men of the time and place represented, make them move as easily as if he held them in strings; and make them speak not only with general conformity to their common position, but with individual and distinctive propriety, so that each is different from the rest? Did he live in ancient Rome, strolling the Forum, or climbing the Capitol; hear ancient matrons converse with modest dignity; listen to conspirators among the columns of its porticoes; mingle among senators round Pompey's statue; or with plebeians crowding to hear Brutus or Antony harangue? Was he one accustomed to idle in the Piazza of St. Mark, or shoot his gondola under the Rialto? Or was he a knight or even archer in the fields of France or England during the period of the Plantagenets or Tudors, and witnessed and wrote down the great deeds of those times, and knew intimately and personally each puissant lord who distinguished himself by his valour, by his wisdom, or even by his crimes? Did he live in the courts of princes, perchance holding some office which enabled him to listen to the grave utterances of kings and their counsellors, or to the witty sayings of court jesters? Did he consort with banished princes, and partake of their sports or their sufferings? In fine, did he live in great cities, or in shepherds' cottages, or in fields and woods; and does he date from John and live on to the eighth Henry—a thread connecting in himself the different epochs of mediæval England? One would almost say so; or multiply one man into many, whose works have been united under one man.

This ubiquity, if we may so call it, of Shakespeare's sympathies, constitutes the unlimited extent and might of his dramatic genius. It would be difficult to imagine where a boundary line could at length have been drawn, beyond which nothing original, nothing new, and nothing beautiful, could be supposed to have come forth from his mind. We are compelled to say that his genius was inexhaustible.

* * * * * *

Many of you, no doubt, are aware that a controversy has long existed, whether the madness of Hamlet is intended by Shakespeare to be real or simulated. If a dramatist wished to represent one of his persons as feigning madness, that assumed condition would be naturally desired by the writer to be as like as possible to the real affliction. If the other persons associated with him could at once discover that the madness was put on, of course the entire action would be marred, and the object for which the pretended madness was designed would be defeated by the discovery. How consummate must be the poet's art, who can have so skilfully described, to the minutest symptoms, the mental malady of a great mind, as to leave it uncertain to the present day, even among learned physicians versed in such maladies, whether Hamlet's madness was real or assumed.

This controversy may be said to have been brought to a close by one of the ablest among those in England who have every opportunity of studying the almost innumerable shades through which alienation of mind can pass.* And so delicate are the changeful characteristics which Shakespeare describes, that Dr. Conolly considers that a twofold form of disease is placed before us in the Danish prince. He concludes that he was labouring under real madness, yet able to put on a fictitious and artificial derangement for the purposes which he kept in view. Passing through act by act and scene by scene, analysing, with experienced eye, each new symptom as it occurs, dividing and anatomising, with the finest scalpel, every fibre of his brain; he exhibits, step by step, the transitionary characters of the natural disease in a mind naturally, and by education, great and noble, but thrown off his pivot by the anguish of his sufferings and the strain of aroused passion. And to this is superadded another and not genuine affection, which serves its turn with that estranged mind when it suits it to act, more especially that part which the natural ailment did not suffice for. Now, Dr. Conolly considers these symptoms so accurately as well as minutely described, that he throws out the conjecture that Shakespeare may have borrowed the account of them from some unknown papers by his son-in-law, Dr. Hall.

But let it be remembered that in those days mental phenomena were by no means accurately examined or generally known. There was but little attention paid to the peculiar forms of monomania, or to its treatment, beyond restraint and often cruelty. The poor idiot was allowed, if harmless, to wander about the village or the country to drivel or gibber amidst the teasing or ill-natured treatment of boys or rustics. The poor maniac was chained or tied in some wretched out-house, at the mercy of some heartless guardian, with no protector but the constable. Shakespeare could not be supposed, in the little town of Stratford, nor indeed in London itself, to have had opportunities of studying the influence and the appearance of mental derangement of a high-minded and finely-cultivated prince. How then did Shakespeare contrive to paint so highly-finished and yet so complex an image? Simply by the exercise of that strong sympathetic will which enabled him to transport, or rather to transmute, himself into another personality. While this character was strongly before him he changed himself into a maniac; he felt intuitively what would be his own thought, what his feelings, were he in that situation; he played with himself the part of the madman, with his own grand mind as the basis of its action; he grasped on every side the imagery which he felt would have come into his mind, beautiful even when dislorded, sublime even when it was grovelling, brilliant even when dulled, and clothed it in words of fire and of tenderness, with a varied rapidity which partakes of wildness and of sense. He needed not to look for a model out of himself, for it cost him no effort to change the angle of his mirror and sketch his own countenance awry. It was but little for him to pluck away the crown from reason and contemplate it dethroned. * * * *

---

* 'A Study of Hamlet,' by John Conolly, M.D., London, 1863.

Mrs. Jameson has well distinguished the different forms of mental aberration in Shakespeare's characters, when she says that "Constance is frantic, Lear is mad, Ophelia is insane."—*Characteristics of Women.* * * * *

It has often been said that in his female characters Shakespeare is not equal to himself. The work to which I have just alluded meets, I think, completely, this objection, which, I believe, even Schlegel raises. It required a lady, with mind highly cultivated, with the nicest powers of discrimination, and with happiness of expression, to vindicate at once Shakespeare and her sex. The difficulty of this task can hardly be appreciated without the study of its performance. Its great difficulty consists in the almost family resemblance of the different portraits which make up Shakespeare's female gallery. There is scarcely any room for events, even for incident, still less for actions, say for bold and unfeminine deeds. Several of the heroines of Shakespeare are subjected to similar persecutions, and almost the same trials. In almost every one the affections and their expression have alone to interest us. From Miranda, the desert-nurtured child in the simplicity of untempted innocence, to Isabella, in her cloistered virtue, or Hermione in her unyielding fortitude — there are such shades, such varying yet delicate tints, that not two of these numerous conceptions can be said to resemble another. And whence did Shakespeare derive his models? Some are lofty queens, others most noble ladies, some foreigners, some native; different types in mind and heart, as in the lineament or complexion. Where did he find them? Where did he meet them? In the cottages of Stratford, or in the purlieus of Blackfriars? Among the ladies of the Court, or in the audience in his pit? No one can say—no one need say. They were the formations of his own quickened and fertile brain, which required but one stroke, one line, to sketch him a portrait to which he would give immortality. Far more difficult was this success, and not less completely was it achieved, in that character which medical writers seem hardly to believe could be but a conception. We may compare the mind of Shakespeare to a diamond, pellucid, bright, and untinted, cut into countless polished facets, which, in constant movement, at every smallest change of direction or of angle, caught a new reflection, so that not one of its brilliant mirrors could be for a moment idle, but by a power beyond its control was ever busy with the reflection of innumerable images, either distinct or running into one another, or repeated each so clearly as to allow him, when he chose, to fix it in his memory. * * * *

The next and most essential quality required for true genius is the *power to give outward life to the inward conception*. Without this the poet is dumb. He may be a "mute inglorious Milton;" he cannot be a speaking, noble Shakespeare. I should think that I was almost insulting such an audience, were I to descant upon Shakespeare's position among the bards and writers of England, and of the modern world. Upon this point there can scarcely be a dissentient opinion. His language is the purest and best, his verses the most flowing and rich; and as for his sentiments, it would be difficult without the command of his own language to characterise them. No other writer has ever given such periods of sentential wisdom. • • • •

I have spoken of genius as a gift to an individual man. I will conclude by the reflection that that man becomes himself a gift: a gift to his nation: a gift to his age; a gift to the world of all time. That same Providence which bestows greatness, majesty, abundance and grace, no less presents, from time to time, to a people or a race these few transcendent men who mark for it periods no less decisively, though more nobly, than victories or conquests. • • • •

It is a double gift that that same creating and directing rule has made this country the birthplace and the seat of the two men who, within a short period, were made the rulers each of a great and separate intellectual dominion, never to be deposed, never to be rivalled, never to be envied. To Newton was given the sway over the science of the civilised world; to Shakespeare the sovereignty over its literature.

The one stands before us passionless and grave, embracing in his intellectual grandeur every portion of the universe, from the stars, to him invisible, to the rippling of the tiny waves which the tide brought to his feet. The host of heaven, that seemed in causeless dispersion, he marshalled into order, and bound in safest discipline. He made known to his fellow-men the secret laws of heaven, the springs of movement, and the chains of connection, which invariably and unchangeably impel and guide the course of its many worlds. • • •

Beside him stands the ruler of that world, which, though ever sublimely intellectual, is governed by him with laws in which the affections, even the passions, the moralities, and the anxieties of life have their share; in which there is no severity but for vice, no slavery but for baseness, no unforgivingness but for calculating wickedness. In his hand is not the staff of authority; whether it take the form of a royal sceptre or of a knightly lance, whether it be the shepherdess's crook or the fool's bauble, it is still the same, the magician's wand. Whether it be the divining rod with which he draws up to light the most hidden streams of nature's emotions, or the potential instrument of Prospero's spells, which raises storms in the deep or works spirit-music in the air, or the wicked implement with which the witches mingle their unholy charm, its cunning and its might have no limit among created things. But it is not a world of stately order which he rules, nor are the laws of unvarying rigour by which it is commanded.

The wildest paroxysms of passion, the softest delicacy of emotions; the most extravagant accident of fortune, the tenderest incidents of home; the king and the beggar, the sage and the jester, the tyrant and his victim; the maiden from the cloister and the peasant from the mountains; the Italian schoolchild and the Roman matron; the princes of Denmark and the lords of Troy—all these and much more are comprised in the vast embrace of his dominions. Scarcely a rule can be drawn from them, yet each forms a model separately, a finished group in combination. Unconsciously as he weaves his work, apparently without pattern or design, he interlaces and combines in its surface and its depth images of the most charming variety and beauty; now the stern mosaic, without colouring, of an ancient pavement, now the flowing and intertwining arabesque of the fanciful East; now the rude scenes of ancient mediæval tapestry like that of Beauvais, and then the finished and richly-tinted production of the Gobelins loom.

And yet through this seeming chaos the light permeates, and that so clear and so brilliant as equally to define and to dazzle. Every portion, every fragment, every particle, stands forth separate and particular, so as to be handled, measured, and weighed in the balance of critic and poet. Each has its own exact form and accurate place, so that, while separately they are beautiful, united they are perfect. Hence their combinations have become sacred rules, and have given inviolable maxims not only to English but to universal literature. Germany, as we have seen, studies with love and almost veneration every page of Shakespeare; national sympathies and kindred speech make it not merely easy but natural to all people of the Teutonic family to assimilate their literature to that its highest standard. France has departed, or is fast departing, from its favourite classical type, and adopting, though with unequal power, the broader and more natural lines of the Shakespearian model. His practice is an example, his declarations are oracles.

Still, as I have said, the wide region of intellectual enjoyment over which our great bard exerts dominion, is not one parcelled out or divided into formal and state-like provinces. While the student of science is reading in his chamber the great "Principia" of Newton, he must keep before him the solution of only one problem. On that his mind must undistractedly rest, on that his power of thought be intensely concentrated. Woe to him if imagination leads his reason into truant wanderings; woe if he drop the thread of finely-drawn deductions! He will find his wearied intelligence drowsily floundering in a sea of swimming figures and evanescent quantities, or floating amidst the fragments of a shipwrecked diagram. But over Shakespeare one may dream no less than pore; we may drop the book from our hand and the contents remain equally before us. Stretched in the shade by a brook in summer, or sunk in the reading chair by the hearth in winter, in the imaginative vigour of health, in the drooping spirits of indisposition, one may read, and allow the trains of fancy which spring up in any scene to pursue their own way, and minister their own varied pleasure or relief; and when by degrees we have become familiar with the inexhaustible resources of his genius, there is scarcely a want in mind or the affections that needs no higher than human succour, which will not find in one or other of his works that which will soothe suffering, comfort grief, strengthen good desires, and present some majestic example to copy, or some fearful phantom. But when we endeavour to contemplate all his infinitely varied conceptions as blended together in one picture, so as to take in, if possible, at one glance the prodigious extent of his prolific genius, we thereby build up what he himself so beautifully called the "fabric of a vision," matchless in its architecture, as in the airiness of its materials. There are forms fantastically sketched in cloud-shapes, such as Hamlet showed to Polonius, in the midst of others rounded and full, which open and unfold ever-changing varieties, now gloomy and threatening, then tipped with gold and tinted with azure, ever-rolling, ever-moving, melting the one into the other, or extricating each itself from the general mass. Dwelling upon this maze of things and imaginations the most incongruous combinations come before the dreamy thought fascinated, spellbound, and entranced. The wild Ardennes and Windsor park seem to run into one another, their firs and their oaks mingle together; the boisterous ocean boiling round "the still vexed Bermoothes" runs smoothly into the lagoons of Venice; the old grey porticoes of republican Rome, like the transition in a dissolving view, are confused and entangled with the slim and fluted pillars of a Gothic hall; here the golden orb, dropped from the hand of a captive king, rolls on the ground side by side with a jester's mouldy skull—both emblems of a common fate in human things. Then the grave chief justice seems incorporated in the bloated Falstaff; king John and his barons are wassailing with Poins and Bardolph at an inn door; Coriolanus and Shylock are contending for the right of human sensibilities; Macbeth and Jacques are moralising together on tenderness even to the brute. And so of other more delicate creations of the poet's mind—Isabella and Ophelia, Desdemona and the Scotch thane's wife produce respectively composite figures of inextricable confusion. And around and above is that filmy world, Ariel and Titania and Peasblossom and Cobweb and Moth, who weave us a gossamer cloud around the vision, dimming it gradually before our eyes, in the last drooping of weariness, or the last hour of wakefulness.

* * * * *

Royal Institution of Great Britain.

1865.

GENERAL MONTHLY MEETING,

Monday, Nov. 6, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

Daniel Chauncy Beale, Esq. and
Protheroe Smith, M.D.

were *elected* Members of the Royal Institution.

The Special Thanks of the Meeting were returned for the following addition to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151):—

Professor Faraday (*3rd donation*)	£20

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

The Board of Trade—Thirteenth Number of Meteorological Papers. 4to. 1865.
Russian Government—Annales de l'Observatoire Physique Centrale de Russie. 1862. 4to. 1865.
United States, Secretary of the Treasury—Statistics of the Commerce of the United States. 8vo. Washington. 1864.
Actuaries, Institute of—Assurance Magazine, Nos. 61, 60. 8vo. 1865.
Agricultural Society, Royal—Journal. Second Series. Vol. I. Part 2. 8vo. 1865.
Airy, G. B. Esq. F.R.S. Astronomer Royal (*the Author*)—Essays on the Invasions of Britain, &c. 4to. 1865.
American Academy of Arts and Sciences—Proceedings, Vol. VI. 23-38. 8vo. 1864.
American Institute of New York—Annual Report, 1861, 1862, 1863. 2 vols. 8vo. 1863.
American Philosophical Society—Transactions, Vol. XIII. Part 1. 4to. 1865.
  Proceedings, Nos. 71, 72. 8vo. 1864.
  Catalogue of Library, Part 1. 8vo.
Antiquaries, Society of—Proceedings, Vol. II. No. 6. 8vo.
  Archæologia, Vol. XXXIX. Part 2. 4to. 1865.
Asiatic Society of Bengal—Journal, Nos. 124, 125, 126. 8vo. 1865.
Asiatic Society, Royal—Journal, New Series, Vol. I. Part 2. 8vo. 1865.
Astronomical Society, Royal—Monthly Notices, 1864-5. Nos. 8, 9. 8vo.

Bache, Professor A. D.—Report on the United States Coast Survey for 1862. 8vo. 1864.

Bavarian Academy of Science, Royal—Sitzungsberichte, 1865. I. 1–4. 8vo.

Belgique, Académie Royale de—Almanach, 1865. 18mo.
Bulletins, 1864, 1865. 8vo.

Boston Society of Natural History, U.S.—Proceedings, Vol. IX. 21-25. 8vo. 1865.

British Association for the Advancement of Science—Report of the Thirty-fourth Meeting, held at Bath, Sept. 1864. 8vo. 1865.

Chemical Society—Journal for June–Sept. 1865. 8vo.

Churchill, Messrs.—Quarterly Journal of Science, No. 8. 8vo. 1865.

Colenso, Right Rev. John William, D.D. Bishop of Natal (*the Author*,—The Pentateuch and the Book of Joshua critically Examined. New ed. 5 vols. 8vo. 1863-5.

Editors—American Journal of Science, July–Sept. 1865. 8vo.
Artizan for July-Oct. 1865. 4to.
Athenæum for July-Oct. 1865. 4to.
Chemical News for July-Oct. 1865. 4to.
Engineer for July–Oct. 1865. fol.
Horological Journal for July-Oct. 1865. 8vo.
Journal of Gas-Lighting for July–Oct. 1865. 4to.
Mechanics' Magazine for July–Oct. 1865. 8vo.
Pharmaceutical Journal for July-Oct. 1865.
Practical Mechanics' Journal for July-Oct. 1865. 4to.

Faraday, Professor, D.C.L. F.R.S.—Kais. Akademie der Wissenschaften. Wien. Sitzungsberichte. Math. Nat. Classe: Abth. I. 1864, Nos. 7-10. 1865. Nos. 1, 2. Abth. II. 1864, Nos. 6-10. 1865, Nos. 1, 2. 8vo.

Franklin Institute—Journal, Nos. 473–476. 8vo. 1865.

Geographical Society, Royal—Journal, Vol. XXXIV. 8vo. 1864.
Proceedings, Vol. IX. Nos. 5, 6. 8vo. 1865.

Geological Institute, Royal, Vienna—Jahrbuch, Band XV. No. 1. 4to. 1865.

Geological Society—Journal, No. 83. 8vo. 1865.

Georgofili, Accademia dei, Firenze—Atti. Nuovo Serie. Vol. XI. 8vo. 1864.

Horticultural Society, Royal—Proceedings, 1865. No. 7. 8vo.

Irish Academy, Royal—Proceedings, Vol. VIII. 8vo. 1861–4.

Lankester, Edwin, M.D. F.R.S. (*the Author*)—Ninth Annual Report of the Medical Officer of St. James's. 8vo. 1865.

Linnean Society—Journal and Proceedings, No. 35. 8vo. 1865.
Transactions, Vol. XXV. Part 1. 1865. 4to.

Longman & Co. Messrs.—St. Bartholomew's Hospital Reports, Vol. I. 8vo. 1865.

Mechanical Engineers' Institution, Birmingham—Proceedings, Nov. 1864; Jan. 1865. 8vo.

Meteorological Society, British—Proceedings, No. 20. 8vo. 1865.

Moore, C. Hewitt, Esq. M.R.I. (*the Author*)—The Antecedents of Cancer. [illegible] 16to. 1865.

Photographic Society—Journal, Nos. 159–162. 8vo. 1865.

Pickburn, J. T. Esq.—Wm. J. Pinks' History of Clerkenwell. 8vo. 1865

Poggioli, Signor G. A.—Alcuni Scritti di M. A. Poggioli. 8vo. 1862–4.

Pratt, Archdeacon John H. (*the Author*)—Treatise on Attractions, Laplace's Functions, and the Figure of the Earth. 3rd ed. 12mo. 1865.

Royal Society of London—Proceedings, No. 76. 8vo. 1865.
Philosophical Transactions for 1865, Vol. CLV. Part 1. 4to. 1865.

Statistical Society of London—Journal, Vol. XXVIII. Part 2. 8vo. 1865.

Smithsonian Institution, Washington, U.S.—Smithsonian Contributions to Knowledge. Vol. XIV. 4to. 1865.
Annual Report for 1863. 8vo. 1864.
Meteorological Observations, Vol. II. Part 1. 4to. 1864.

Taylor, Alfred S. M.D. F.R.S. (*the Author*)—Principles and Practice of Medical Jurisprudence. 8vo. 1865.

Twining, Henry. Esq. M.R.I. (the Author)—Elements of Picturesque Scenery. Vol. III. Part I. 8vo. 1865.
United Service Institution, Royal—Journal, May-July. 8vo. 1865.

Gray, Dr. J. E.—Medallion of Dr. J. E. Gray and Mrs. Gray.

GENERAL MONTHLY MEETING,

Monday, Dec. 4, 1865.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

The Hon. Robert Bourke.
The Viscount Cranborne, M.P.
The Rev. John Henry Ellis, M.A.
John Heugh, Esq.
Sir Edward Hilditch, M.D. and
Stavely King, M.D.

were *elected* Members of the Royal Institution.

Lecture Arrangements for the ensuing Season:—

Christmas Lectures, 1865-66. (*Adapted to a Juvenile Auditory.*)

Prof. Tyndall, F.R.S.—Six Lectures 'On Sound.'

Before Easter, 1866.

Prof. Tyndall, F.R.S.—Ten Lectures, 'On Heat.'

Prof. Frankland, F.R.S. — Eight Lectures, 'On the Non-Metallic Elements.'

Prof. R. Westmacott, R.A. F.R.S.—Six Lectures, 'On Art-Education, and how Works of Art should be viewed.'

Rev. G. Henslow.—Four Lectures, 'On Structural and Systematic Botany, considered with reference to Education and Self-instruction.'

After Easter.

Prof. Frankland, F.R.S.—Four Lectures, 'On the Non-Metallic Elements.'

An Extra Course of Three Lectures, On 'Muscular Contraction,' by Dr. Du Bois Reymond.

G. Scharf, Esq. *Secretary and Keeper of National Portrait Gallery.*—Three Lectures, 'On National Portraits.'

Rev. C. Kingsley, M.A.—Two Lectures, 'On Science and Superstition.'

Prof. Huxley, F.R.S.—Twelve Lectures, 'On the Methods and Results of Ethnology.'

Prof. Ansted, F.R.S.—Five Lectures, 'On the Application of Physical Geography and Geology to the Fine Arts.'

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same: viz.—

FROM

The Lords of the Admiralty—The Nautical Almanac for 1868 and 1869. 8vo. 1864–5.

The Board of Trade—Fourteenth Number of Meteorological Papers. 4to. 1865

Astronomical Society, Royal—Memoirs, Vol. XXIII. 4to. 1865.

British Architects' Institute, Royal—Sessional Papers, 1865–6. Part I. No. 1. 4to.

British Pharmaceutical Conference—Proceedings. 1865. 8vo.

Chemical Society—Journal for Oct. 1865. 8vo.

De la Rive, M. Aug. (the Author)—Discours prononcé le 24 Août. 1865. 8vo. (Bibl. Universelle de Genève. Tome XXIV.)

De la Rue, Warren, Esq. Balfour Stewart, Esq. and Benjamin Loewy, Esq. (the Authors)—Solar Physics. First Series. (Phil. Trans. R.S. 1865.)

Editors—Artizan for Nov. 1865. 4to.
Athenæum for Nov. 1865. 4to.
Chemical News for Nov 1865. 4to.
Engineer for Nov. 1865. fol.
Horological Journal for Nov. 1865. 8vo.
Journal of Gas-Lighting for Nov. 1865. 4to.
Mechanics' Magazine for Nov. 1865. 8vo.
Pharmaceutical Journal for Nov. 1865.
Practical Mechanics' Journal for Nov. 1865. 4to.

Genève, Société de Physique—Mémoires. Tome XVIII. Partie 1. 4to. 1865.

Geological Society—Journal, No. 84. 8vo. 1865.

Greenwich Observatory (by Royal Society)—Greenwich Observations for 1863. 4to. 1865.

Horticultural Society, Royal—Proceedings, 1865. No. 8. 8vo.

Lankester, Edwin, M.D. F.R.S. (the Editor)—Journal of Social Science, No. 1. 8vo. 1865.
Address at Sheffield, Oct. 9, 1865. 8vo.

Lee, Robert, M.D. F.R.S. (the Author)—History of the Discoveries of the Circulation of the Blood of the Ganglia and Nerves, and of the Action of the Heart. 8vo. 1865.

Medico-Chirurgical Society, Royal — Medico-Chirurgical Transactions, Vol. XLVIII. 8vo. 1865.

Moore, Charles Hewitt, Esq. M.R.I.—Dr. Tregelles' Greek Testament. Part III. 4to. 1865.

Photographic Society—Journal, No. 163. 8vo. 1865.

Royal Society of Edinburgh—Transactions, Vol. XXIV. Part 1. 4to. 1865.
Proceedings, Nos. 65, 66, 67. 8vo. 1864–5.

Tate, George, Esq. (the Author)—The Ancient British Sculptured Rocks of Northumberland. 8vo. 1865.

Wilson and Beadell, Messrs.—Photographic Portraits of Sir Ranald Martin, F.R.S. William Fergusson, Esq. F.R.S. and Erasmus Wilson, Esq. F.R.S.

1866.

WEEKLY EVENING MEETING,

Friday, January 19, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

John Tyndall, Esq. LL.D. F.R.S.
Professor of Natural Philosophy, R.I.

On Radiation and Absorption with reference to the Colour of Bodies and their State of Aggregation.

The speaker referred to the relation subsisting between the sensible phenomena of nature, and those processes lying beyond the range of the senses, on which the phenomena immediately depend. He spoke of the function of the imagination in picturing operations, which though great in their aggregate results beyond all conception, are too minute individually to be capable of observation. He referred to the luminiferous ether that fills space as the most striking illustration hitherto known of the production of a line of thought from the domain of the senses into that of the imagination, and affirmed the existence of this wonderful medium to be based upon proofs at least as strong as those which sustain the theory of gravitation.

Dwelling briefly on the relation of this ether to the atoms and molecules which are plunged in it, he illustrated, by reference to the phenomena of sound, the difference between good and bad radiators. A naked tuning-fork vibrating in free air imparted so small an amount of motion to the air that it ceased to be heard as sound at an inconsiderable distance; the same tuning-fork brought into union with its resonant case produced a sound which could be heard by thousands at once. The naked fork was a bad radiator, the combined fork and case was a powerful radiator. This combination of the fork and its case, as regards sound, roughly represented the influence of chemical combination as regards radiant heat. By the act of combination the power of the combining atoms as radiators might be augmented ten thousand-fold. As an example of this the vapour of water was selected; and it was affirmed that a pound of this vapour taken to the top of a high mountain, there heated and exposed before the cloudless heaven, would radiate nine or ten thousand times—possibly twenty thousand times—as much heat into stellar space as could be radiated by either of the constituents of the vapour when uncombined.

The speaker also referred to the well-known analogy between the pitch of a sound and the colour of light, and throwing a large spectrum upon a white screen mentioned the relation between the various colours to the rapidity of ethereal vibration. The space from the red to the blue embraced an infinite number of rates of vibration, gradually and continuously shortening without any interruption. It might be typified by an infinite number of tuning-forks of gradually augmenting pitch, and all sounding at the same time. This spectrum was derived from the carbon points of the electric light; but it was shown that in the case of various other incandescent substances the spectrum was not of this continuous character. The magnificent stream of green light produced by the volatilization of silver in the electric lamp was shown upon a screen, and afterwards the light was analyzed and found to produce two bands of brilliant green, differing but slightly from each other in refrangibility. Here the case is typified, not by an infinite number of tuning-forks, but by two tuning-forks of slightly different pitch. And just as the rate of vibration in the case of the tuning-fork is a fixed rate, so the rate of vibration of the atoms of silver vapour were fixed. And as the colour of the vapour depended on its rate of atomic vibration, the constancy of this rate secured the constancy of colour in the vapour. We cannot make the vapour of silver *white hot*, however we may exalt its temperature. We may augment the brilliancy of the particular rays that it emits, but we cannot cause it to emit that variety of rays the blending of which together produces the impression of white.

Like the vapour of silver the vapour of water has also its definite periods of vibration; and they are not such as to enable the vapour, however high its temperature may be raised, to emit a white light. It can hardly be said to emit any light at all. The flame of hydrogen, for example, is composed of intensely heated aqueous vapour, but it is hardly visible; and it is easy to give the vapour of water a temperature sufficient to raise a solid body placed in the vapour to a bright red heat, while the vapour itself remains absolutely dark. Now the powers of radiation and absorption go hand in hand, and the body which cannot emit luminous rays is incompetent to absorb them. Thus the sun's luminous rays pass freely through the aqueous vapour of our atmosphere; while it is the impediment offered by this same vapour to the radiation from the earth which checks the sudden drain of terrestrial heat, and thus renders our planet inhabitable.

This power of electric absorption was illustrated by the action of two tuning-forks which sounded the same note. Both forks being mounted on their resonant stands, one of them was first sounded. The silent fork was then brought near the sounding one, and held near it for five seconds. The vibrations of the excited fork were then quenched, but the sound did not cease to be heard. In fact the silent fork had taken up the vibrations of its neighbour, and continued to sound after the latter had ceased to vibrate. Again, one fork being permitted to remain upon its stand, the other was dismounted and thrown into strong vibration. Detached from its stand, its sound was too feeble to be heard by the audience; but on bringing it near the mounted fork a mellow sound rose which filled the room. Thus the vibrations of the one fork were transmitted through the air and imparted to the other. To effect this transference it was necessary that the forks should be in perfect unison: the fixing upon either of them of a bit of wax not larger than a pea was sufficient to destroy the power of the forks to influence each other.

Thus one sounding body absorbs the vibration of another sounding body with which it is in unison; and here we have in acoustics the representative of that great principle which in optics lies at the base of spectrum analysis, namely, that bodies absorb those rays which they can themselves emit. Thus green vapour of silver if interposed in the path of a beam of white light, will absorb the green which it can itself emit. Thus also the incandescent vapour of sodium, itself intensely yellow, cuts clearly out the yellow band of the spectrum. And the same is true of aqueous vapour. Its periods of vibration synchronize with those of the rays, or more accurately *waves*, emitted by the warmed earth, and hence its power to intercept those waves by taking up their motion. But it is in dissonance with the luminous waves emitted by the sun, and hence those waves pass through large quantities of it with scarcely sensible absorption.

This incompetence of aqueous vapours to absorb luminous rays is shared by all really transparent bodies; in fact, they are transparent in virtue of their incapacity to absorb luminous rays. Now, transparent bodies in a state of powder are always white, and in white bodies luminous rays have no power. The *light* of the sun, for example, cannot warm white sugar, nor can it warm table salt, nor flour, nor a white dress; it cannot even melt snow. The most powerful luminous beam may be concentrated upon a surface covered with hoar frost without melting a single spicula of the frost crystals. How, then, it may be asked, does sunshine clear away the snow from the mountain heads? Two or three days' sunshine on the mountains suffices to obliterate the traces of a heavy snow-fall: how can this occur if sunshine has no power to melt the snow crystals? It is not the luminous rays of the sun which perform this work, but a body of rays which, though possessing high calorific power, have no light in them. By a process of transmutation these dark rays may be converted into luminous ones, but as they come from the sun, and fall upon the mountain summits, they are utterly incompetent to excite vision. Every stream which channels the glaciers or tumbles down the valleys of the Alps is the direct product of this invisible radiation. To it also the glaciers owe their birth as well as their dissolution. For while the luminous rays of the sun falling on the tropical ocean penetrate the water to great depths without considerable absorption, the dark rays are in great part absorbed close to the surface of the ocean; they therefore heat the water at the surface, and are thus almost the sole excitants of evaporation. Not only, then, do those invisible solar rays, by the fusion of the ice, give birth to the rivers of Switzerland, but it is they that lift the material of these rivers from the sea and store it on the frozen summits of the mountains.

Gathering up the rays emitted by a powerful electric lamp, and concentrating them upon a small focus, water, alcohol, or ether placed at the focus speedily boils, some of them, indeed, almost instantly. But they are not boiled by the luminous rays, though these produce an impression too dazzling to be borne upon the eye. Interposing in the path of the concentrated beam a glass cell containing pure distilled water, the light of the beam is not sensibly diminished, but it is no longer competent to boil or even heat water at the focus. Placing a piece of ice at the luminous focus it is not melted, though, if blackened wood be placed there, it is set on fire. The moment, however, the cell of water is withdrawn the ice melts—melts because the dark rays previously absorbed by the water of the cell are now absorbed by it. There are liquids of very low boiling points—bisulphide of carbon, for instance—which, when placed at the focus where the whole radiation, dark and bright, of the electric lamp is converged, cannot be caused to boil, can hardly be warmed. Water, for instance, requires a temperature of 212° Fahr. to boil it, bisulphide of carbon requires only 118° 4′; still the former is boiled in a time insufficient to warm the latter. This arises from the fact, that while water powerfully absorbs the dark calorific rays and allows the luminous ones free transmission, the bisulphide of carbon is transparent to both classes of rays, and hence is warmed by neither of them. Thus, also, when it was stated that sugar could not be warmed by the *light* of the sun, the invisible solar rays were meant to be excluded, for when the *total* radiation of the sun is converged upon white sugar it is immediately burnt up, the agent of its combustion being, however, the dark radiation.

It is possible to filter the composite radiation from the sun or from the electric light, so as to detach almost completely the visible from the invisible rays. It has been already stated that bisulphide of carbon is transparent to both classes of rays; now iodine, a substance which dissolves freely in the bisulphide, is eminently transparent to the invisible rays alone. Hence, a combination of these two substances furnishes us with a *ray-filter*, which, while it pitilessly cuts off the bright rays, allows the dark ones free transmission. At the dark focus we can boil water or alcohol, but we cannot warm bisulphide or bichloride of carbon. Bromine also, notwithstanding its volatility, bears exposure at the focus without being heated. Sulphur also bears the temperature of the focus for a considerable time without ignition. Common phosphorus, a combustible so quick that the warmth of the fingers when in *contact* with it suffices to provoke combustion, bears for twenty or thirty seconds without ignition the action of *radiant heat* at a focus where, in the fraction of a second, platinized platinum is raised to a white heat. The phosphorus is in a great degree transparent to radiant heat. The red iodide of mercury strewn on paper and exposed at the focus has its colour discharged where the invisible images of the carbon points fall upon it, but owing to the transparency of the iodide to radiant heat, it requires some exposure to produce the thermograph. This red substance is far less absorbent of radiant heat than white paper, and hence it is sometimes easier to obtain a thermograph of the carbon points by exposing to the radiation from the lamp the *back* of the paper on which the iodide is strewn, than by exposing the face covered with the iodide. It is often, indeed, more easy to *burn* a thermograph through the paper than to discharge the colour of the iodide. Hence, white paper may be protected from radiant heat by being covered with a substance like the iodide of mercury.

We are here naturally reminded of the experiments of Franklin, which consisted in placing cloths of various colours upon snow, and observing the depth to which they sank in the snow when exposed to direct sunshine. Franklin concluded that the lighter the colour of the body the less is its power of absorption. The generalizations founded on this experiment are for the most part fallacious. Results long ago obtained, establishing the vast influence of chemical constitution on radiant heat, led the speaker to contrast iodine, an element, with alum, a body of highly complex character. Both substances were in powder, the one being dark, the other white. Exposed to the radiation from various sources, the white powder proved itself in all cases the most powerful absorber. The dark powder of amorphous phosphorus was also compared with the hydrated oxide of zinc, but the white powder was the best absorber. Bodies of the same colour compared together showed similar differences. The red oxide of lead for example was contrasted with the red iodide of mercury, and the oxide proved the most powerful absorber. So also the white chloride of silver was compared with the white carbonate of lead, the lead salt proved by far the most powerful absorber. In this way it was proved that as regards the absorption of radiant heat, white in some cases exceeds black, black in some cases exceeds white, and the other colours are equally capricious; all evidently depending on the chemical constitution of the substances. Here, as in other cases moreover, radiation and absorption go hand in hand, the substance which absorbs heat most powerfully radiating the same heat most copiously.

In the case of Franklin's white cloth exposed on snow to sunshine, there is no reason why it should sink at all; there is, on the contrary, reason to conclude that it must rise relatively to the snow surrounding it. For, as regards the luminous rays of the sun, they are alike powerless to warm the cloth or to melt the snow. Whatever effect is produced is therefore due to the dark solar rays. Now, snow absorbs these rays with greater greediness than any other substance; hence the white cloth, which absorbs less than the snow, really defends the snow underneath it from the action of the sun, and owing to this protection the cloth, if exposed for a sufficient time, will rise in relation to the surface round, just like a glacier table.

But though the cloth is not so good an absorber as the snow, it is nevertheless a very powerful absorber; it comes near the snow in this respect. And when, as in the case of the black cloth, we have added to the absorption of a large portion of the dark rays by the cloth, the absorption of the whole of the luminous rays by the dye, the sum of the absorption of both classes of rays exceeds the absorption by the snow of the dark rays alone. The black cloth will therefore sink in the snow. This is the explanation of Franklin's experiment.

The speaker concluded by referring to various experiments on the transmission of radiant heat through rock salt; to the influence of science as a means of intellectual culture; and to the necessary defects of any system of education in which the study of nature is neglected or ignored.

[J. T.]

WEEKLY EVENING MEETING,

Friday, January 26, 1866.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President.
in the Chair.

SAMUEL W. BAKER, Esq.

On the Sources of the Nile.

THE primary object of geographical exploration is the opening to general intercourse such portions of the earth as may become useful to the human race. The explorer is the precursor of the colonist, and the colonist is the instrument by which the great work must be constructed, that greatest and most difficult of all undertakings, the civilization of the world.

The progress of civilization is dependent upon geographical position. The surface of the earth presents certain facilities, and obstacles to general access; those points which are easily attainable must always enjoy a superior civilization to those that are cut off from association with the world.

We may thus assume that the advance of civilization depends upon means of transport; countries remote from the sea may through the ingenuity of man be rendered accessible; the natural productions of those lands may be transported to the sea coast in exchange for foreign commodities, and commerce thus instituted becomes the pioneer of civilization.

Rivers are the natural arteries of the world; providing channels of communication, they have been from the earliest ages the most important geographical phenomena.

Countries that are blessed with navigable rivers invariably prosper;

the ancients were so cognizant of this fact that all first settlements were made upon the banks of rivers, and the origin of the human race dates from an Eden between the Tigris and Euphrates.

London upon the Thames is a mighty fact significant of the importance of river communication. America, that giant offspring of Great Britain, owes her unexampled prosperity to her navigable rivers.

Accepting the theory that rivers are the most important geographical points, we turn with increased interest to that great artery of Africa now before us; that mysterious stream which has ever absorbed the attention of both ancient and modern geographers—the Nile.

Egypt has been created by the Nile. The great Sahara, that frightful desert of interminable scorching sand which stretches from the Red Sea to the Atlantic, is cleft by one solitary thread of water. Ages and ages before man could have existed in that inhospitable land, this thread of water was at its silent work; year after year it flooded and fell, leaving a rich legacy of soil upon the barren sand, until the delta was created; and man, at so remote a period that we have no clue even to an approximate date, occupied the fertile lands thus born of the river Nile, and that corner of savage Africa rescued from its barrenness became Egypt.

The Egyptians claimed the most ancient origin; their geographical position gave them extraordinary advantages for commercial enterprise. Bounded on the east by the Red Sea, on the north by the Mediterranean, while the fertilizing Nile afforded inland communication, Egypt became in the earliest era the most civilized and prosperous country of the earth.

Egypt not only was created by the Nile, but the very existence of the Egyptians depended upon the annual inundation by that river; thus, all that pertained to the Nile was of vital importance to the people; it was the *hand* that fed them.

Two thousand five hundred and eighty years ago a graduated pillar was erected as a nilometer in a well on the island of Rhoda, opposite old Cairo, and the rise and fall of the river was measured and watched with equal anxiety to the present day.

A century later, a canal was commenced by Pharaoh Necho to connect the Nile with the Red Sea; the undertaking failed, but was subsequently completed after the Persian conquest, and water communication was thus established between the Red Sea and the Mediterranean. Egypt was the Nile and the Nile was Egypt.

Depending so entirely upon the river as Egypt did, it was natural that the mysterious origin of those sacred waters should absorb the speculations of all thinking men. It was unlike all other rivers. In July and August, when European streams were at their lowest in the summer heat, the Nile was at the flood!

In Egypt there was no rainfall. Not even a drop of dew in those parched deserts through which the glorious river flowed for 860 thirsty miles of latitude without one single tributary. Licked up by the burning air, and gulped down by the exhausting sand of Arabian deserts, nevertheless it flowed; supporting all losses by evaporation and absorption, the noble flood shed its annual blessings upon Egypt. An anomaly among rivers; flooding in the dry season; everlasting even in sandy deserts; where was its hidden origin? where were the “Sources of the Nile?”

The “Source of the Nile” was, from the earliest period, the great geographical question to be solved. Thus, in the ancient days of Egypt, her kings and priests endeavoured to unravel this great mystery, and to explain the cause of the annual flood, upon which the existence of the Egyptians depended.

The most important event of Jewish history commenced about 1706 B. C., when the family of Joseph came from Canaan into Egypt to purchase corn during the seven years of famine; and thus commenced the settlement of the Israelites among the Egyptians. The colonization was due to the river Nile. Seven years of unprecedented fertility must have been due to seven seasons of extreme inundation, which so filled the granaries of Pharaoh, that he supported the whole population of Egypt during seven succeeding years of famine. That famine must have been caused by the low level of the river Nile. There was famine, *i. e.* want of rain in Canaan, and this drought must have extended to the mountain range in Abyssinia, and have exhausted the great tributaries to the Nile from that country. These tributaries are the Atbara, Settite or Taccazy, Salaam, Angrab, Rahad, Dinder, and the great Blue Nile.

We thus find, as far back as 3570 years, the proof that the population of Egypt had originally been induced by the Nile, as the fertility produced by that extraordinary river not only supported the people of Egypt, but attracted in times of scarcity emigrants from far countries, as exemplified by the colony of Israelites. Everything connected with Egypt was so dependent upon the Nile, that even one of the seven plagues was a disturbance of its waters.

[*] “And the fish that was in the river died; and the river stank, and the Egyptians could not drink of the water of the river; and there was blood throughout all the land of Egypt.”

“And all the Egyptians digged round about the river for water to drink; for they could not drink of the water of the river.”

Doubtless this plague was caused by so low a level of the Nile that the current ceased, and the water stagnating gave birth to a mass of animalculæ of a crimson colour, resembling blood. This is proved by the words “they digged round about the river for water to drink.”

This custom prevails at the present day among the Arabs, who refuse to drink the water of the White Nile from the river when low, on account of minute worms that affect the stomach.

Following this curse upon the river in the reign of Pharaoh, is the plague of frogs: “And the river shall bring forth frogs abundantly,”[†] &c.

---

[*] Exodus, vii. 21-24.

[†] Exodus, viii. 3.

The appearance of frogs in such myriads is a further proof of the general stagnation of the river, caused by an extraordinary dry season.

These striking facts, handed down to us by Sacred History, give a peculiar interest to the Nile. Civilization and learning had sprung from the banks of the Egyptian river—we hear of Moses, that he was "learned in all the wisdom of the Egyptians." But although Egypt was at that period the centre of the world in all that related to science and civilization, and dependent upon the river for its actual existence, not all the learning and wisdom of the Egyptians could determine the "*Sources* of the Nile."

Time will not permit me to allude to the expeditions that, during some thousand years, have been framed by various nations for this discovery. All failed until our countryman, Bruce, discovered the source of the Blue Nile about ninety years ago. He was the first Englishman who had started upon this mysterious mission. Bruce confessed that the Blue Nile was not the great river, but merely a tributary to the main stream known as the White Nile. Numerous expeditions have started since that time to explore the acknowledged Nile,—to seek for the sources of the White river. All failed; a fatality hung over those marshy regions of inner Africa, and the Nile sources seemed doomed to remain for ever sealed. There appeared to be insurmountable difficulties from the north, and it was reserved for the honour of England to send an expedition to the south *viâ* Zanzibar. In command of this expedition, struggling forward with British tenacity of purpose, our gallant explorers, Speke and Grant, reached the first Nile source in the Victoria Lake.

In the very heart of Africa, in N. lat. 4° 55′, I met those great men with open arms. Gaunt and lean with toil and bad climate, but elate with having accomplished that which had baffled the whole world, on the 15th February, 1863, they marched into Gondokoro at the head of the faithful eighteen followers who had started with them from Zanzibar.

It would be vain to attempt the description of this meeting. For nearly two years I had been exploring the tributaries of the Nile, absorbed with the one idea of discovering its true source, and of meeting my old friend Speke in some dilemma from which I had a Quixotic hope of extricating him.

Having completed the exploration of all the great rivers from Abyssinia, I had descended the Blue Nile to Khartoum, at which place I had organized a powerful expedition for the White Nile. To overcome the great difficulty of Central Africa, "want of transport," I had purchased a number of beasts of burden, including horses, camels, and asses, all of which, to the number of twenty-nine, I conveyed up the White Nile in three vessels, and I landed them safe in Gondokoro in lat. 4° 55′ on 3rd Feb., 1863.

The voyage from Khartoum to Gondokoro occupied forty-five days. Nothing can be more tedious than this journey through interminable marshes and vast flats of high reeds and papyrus. Well might the ancient expeditions have returned disheartened from so mournful and hopeless a prospect. Throughout the whole course of the White Nile there is not a mountain until Gondokoro is reached. There, the scenery changes suddenly; the boundless marshes cease, and dry land is gladly welcomed; evergreen trees, native villages and distant hills, and mountain ranges, relieve the eye long wearied by unvarying swamps.

I had been twelve days waiting at Gondokoro for the arrival of a trader's party from the south with whom I had intended to travel, and to form a depôt of heavy baggage at their most advanced station, when they suddenly arrived, bringing with them Speke and Grant.

Delighted as I was to have thus met them, I was nevertheless disappointed. At the first blush it appeared that the great work was completed; and that my expedition, organized at great cost and labour, must fruitlessly return.

Speke relieved me from this despair by giving me a sketch of his route, showing that in N. lat. 2° 17′ the Nile that he crossed below Karuma Falls turned suddenly to the west, and, according to native reports, it fell into a great lake called the Luta N'zige. Thus his exploration was incomplete.

There was evidently much to be done to clear up a most important point, and I immediately determined, if possible, to accomplish it. It lay heavily upon poor Speke's heart that he had been unable to follow up that portion of the river. He said—"Geographers at home will raise a question upon this unexplored point, and they will forget how hard we have worked to get through what we have done." I comforted him with the promise that I would not return without completing the work desired. Speke and Grant sailed from Gondokoro for England. As I watched their boat disappearing in the distance I felt the importance of my responsibility. Bruce had succeeded on the Blue Nile. Speke and Grant had won the Victoria Source. All nations, excepting England, had failed; and the honour of England for the third expedition to the Nile Sources rested upon my head. Had I been alone, it would have been no hard task to die upon the untrodden ground before me, but there was one who, although my greatest comfort, was also my greatest care—one whose presence through years of toil and wandering, whether in scorching deserts or beneath the shade of some pitying tree, had made each spot my home, and with a devotion which exists only in a woman's heart had determined to share my dangers and fatigues. This was my wife; what would be her fate in the very heart of Africa, among savages, should I die?

I was prepared to start; my party consisted of forty-five men well armed; but my difficulties were about to commence.

The whole of the so-called trade of the White Nile is a system of robbery and murder combined with the slave trade; the atrocities committed by the parties employed by the traders are beyond description

—robbery of vast herds of cattle from the unfortunate natives is the acknowledged "*trade;*" and the cold-blooded murder of the tribes is the pastime of the ruffians who compose the ivory trading parties.

My men, who, as inhabitants of the Soudan, had formerly been engaged in these practices, mutinied when I was about to start, refusing to proceed, as in my service they would not be allowed to indulge in slave hunting and pillage. They threatened to fire simultaneously at me should I attempt to disarm them; and all the trading parties amounting to about 600 armed men threatened to repel me by force of arms from the interior should I attempt to advance. My escort dispersed, and joined the various slave hunting parties, leaving me utterly helpless. By dint of careful management I at length induced seventeen of my mutineers to start from Gondokoro; I resolved to quit at all hazards that nefarious spot, trusting that I should gain influence over my men when once in the interior. They consented to start on the condition that I should travel *east;* my intended course was *south*. I discovered that they had conspired to desert me at a trader's station, seven days' march east of Gondokoro in the Latooka country, and to murder me should I attempt to disarm them. With this escort I started at night on the 26th March, 1863, without one native attendant; not an interpreter, nor even a guide being procurable. I followed a few hours' march behind a trader's party that had started on that afternoon, trusting to overcome their hostility by all-powerful gold upon the road.

After seven days' march through a mountainous and fertile country, passing the Bari and Ellyria tribes, we arrived at Latooka, about 100 miles east of Gondokoro. The promised mutiny broke out; several of my men deserted with their arms and ammunition and joined a slave hunting party. This party of upwards of 100 men, armed with guns, attacked a native village on the mountains; but the Latookas fought bravely, and the slave hunters, losing their way in a hasty retreat down the rocky mountain, were forced over a precipice by the natives, and massacred almost to a man; my mutineers being among the slain. This accident was of great service to me; my remaining men regarded the fate of their late comrades as the effect of the "evil eye," and were persuaded that I was in some way connected with the disaster.*

I had by presents reduced a hostile trader's party to cold civility, and I accompanied them forty miles S.W. to Obbo in lat. 4° 2′, thus, although I had marched 140 miles, I was then only fifty-three miles in a direct line farther south than Gondokoro. Obbo is a plateau 3,600 feet above the sea; a high range of mountains separates it from the valley of Latooka on the east, which forms the watershed of the country; the western side draining to the Nile, while the east side drains into the Kanieté river through the Latooka valley to the river Sobat. Obbo, situated among high mountains, has a great rainfall from February to November. With the commencement of the rains the Tsetse fly appears, and every one of my animals died in this fatal spot.* Being quite helpless, without means of transport, I endeavoured to gain the confidence of a neighbouring trader's party by daily repairing their guns, doctoring their sick and wounded, and acting as umpire in all their disputes for many months, until in January 5, 1864, the rains having ceased, the rivers in advance were fordable, and I started south towards Unyoro, in which country the reported lake was supposed to exist. I had exchanged nearly all my clothes and shoes with the trader's people for provisions. I had also purchased a number of oxen from them in exchange for guns. These I trained for riding; and leaving nearly all my baggage, I left Obbo with a few porters to carry blankets and ammunition, &c., and presents for king Kamrasi.

---

* The Latookas are a splendid race of savages, inhabiting a beautiful country of mountain and plain; they are extremely wealthy, possessing immense herds of cattle, and cultivating a variety of grain upon an extensive scale. They are a warlike race, but I found them particularly friendly, as I fraternized with them after their attack on the slave-hunters. Like all the tribes of that part they are good blacksmiths, although their tools are limited to a cleft stick for tongs, and two stones for hammer and anvil.

The Latookas are the only tribe that I left with regret; but it was necessary to push for Unyoro.

We crossed the Atabbi river in 3° 45′, a perennial stream of considerable volume, flowing into the Asua river. We arrived at the Asua in lat. 3° 12′. That river flows through a deep valley, 1,100 feet below the general level of the Obbo country. It was nearly dry at that season, January 9th, where I crossed above the junction of the Atabbi, and a slight stream only ankle-deep trickled down its rocky bed. Although the Asua during the rains is fifteen feet deep, about 120 yards wide, with a violent current, it is a simple mountain torrent, being absolutely nil in the dry season. The country rises rapidly on the south bank of the Asua to an equal elevation to that of Obbo; it is therefore the main drain of that portion of the country. Six days' march south of the Asua we arrived at Karuma Falls, at the ferry where Speke and Grant had crossed, and where they had left the river running from them due west.

Up to this point from Latooka the country had been very lovely, diversified with granite mountains, forests, prairies, and well watered with numerous rivulets, but very thinly populated. The natives perfectly naked, all equally ignorant of a Supreme Being, without any idea of worship, and free from even a vestige of superstition.

---

* The chief of Obbo—"Kachiba"—was the great magician of this country, but he confessed that his magic was of no avail against the flies which killed all cattle in his country. He was a renowned rain-maker, and he declared that he had a house full of thunder and lightning and rain quite at his own disposal for the crops, but he could do nothing with the flies who would assuredly kill my animals. Unfortunately his prophecy was true.

This old chief had 116 children living, and was a charmingly quaint old "pater familias." He told me that he was not naked from choice but from necessity, and he begged for clothes; not for mine fortunately, as I had none to give him, but for *my wife's*. He was quickly attired in lady's costume, to the great delight of his people and the admiration of his wives.

Like most Africans they were very averse to labour, and their time was passed in singing, dancing, drinking a fermented gruel, and committing raids upon their neighbours' cattle.

Many parts of the country had been utterly devastated by the slave traders; villages were reduced to ashes, and the population scared away, while hundreds were murdered or carried into slavery.

The last five days' march had been through uninhabited prairies; we now arrived at the Karuma Falls, and the passage of this portion of the Nile into the country of Unyoro was to introduce a totally distinct people.

After a day lost in obtaining permission to cross the river, a canoe was paddled from the Unyoro side, and we were ferried across about an hour after sunset. By the light of a fire the boatman showed me a string of blue beads that Speke had given him. It is impossible to describe the interest that so trifling an event occasioned, when in that wild country I came for the first time upon the track of my poor friend Speke.

On the following morning the natives positively refused to permit the passage of my men across the river, until they should receive orders from the king Kamrasi; we were thus cut off from the main party. The river was about 150 yards in width, boiling through a succession of rapids in its course west between high cliffs covered with bananas, and a great variety of foliage.

This was the first spot at which I had met with the banana.

For many days it was impossible to proceed south: the capital of Unyoro was about forty miles distant, and the king sent word that "big men were not in a hurry to pay visits, therefore I must wait." At length his majesty condescended to send for me, but we were twelve days marching forty-two miles, as spies were ordered to report upon our conduct daily; and we were systematically detained until messengers returned from Kamrasi.*

At length, after much patience exhausted, we arrived at the capital M'rooli, the residence of the king. We had marched from Karuma Falls parallel with the Nile due south, and at the junction of the Kafoor river in lat. 1° 37′ we were shown a few poor huts on a miserable swamp opposite the town, which were to form my camp.

---

* The people of this country were far superior in intelligence to any that I had seen. They were excellent smiths, using iron hammers instead of stones; they drew wire; made good pottery; they prepared superior tobacco; and manufactured very neat pipes; they worked fine braid of the plantain fibre, and cultivated their ground in a superior manner. Plantains were the staple food, and a variety of sweet potatoe, beans, and Indian corn. Their dress consisted of cloth made of the bark from a species of fig-tree; this tree was largely cultivated, and it was the custom for a newly-married man to plant a certain number in his garden, which were to be the tailors of the expected family.

although I had marched 140 miles, I was then only fifty-three miles in a direct line farther south than Gondokoro. Obbo is a plateau 3,600 feet above the sea; a high range of mountains separates it from the valley of Latooka on the east, which forms the watershed of the country; the western side draining to the Nile, while the east side drains into the Kanieté river through the Latooka valley to the river Sobat. Obbo, situated among high mountains, has a great rainfall from February to November. With the commencement of the rains the Tsetse fly appears, and every one of my animals died in this fatal spot.* Being quite helpless, without means of transport, I endeavoured to gain the confidence of a neighbouring trader's party by daily repairing their guns, doctoring their sick and wounded, and acting as umpire in all their disputes for many months, until in January 5, 1864, the rains having ceased, the rivers in advance were fordable, and I started south towards Unyoro, in which country the reported lake was supposed to exist. I had exchanged nearly all my clothes and shoes with the trader's people for provisions. I had also purchased a number of oxen from them in exchange for guns. These I trained for riding; and leaving nearly all my baggage, I left Obbo with a few porters to carry blankets and ammunition, &c., and presents for king Kamrasi.

We crossed the Atabbi river in 3° 45′, a perennial stream of considerable volume, flowing into the Asua river. We arrived at the Asua in lat. 3° 12′. That river flows through a deep valley, 1,100 feet below the general level of the Obbo country. It was nearly dry at that season, January 9th, where I crossed above the junction of the Atabbi, and a slight stream only ankle-deep trickled down its rocky bed. Although the Asua during the rains is fifteen feet deep, about 120 yards wide, with a violent current, it is a simple mountain torrent, being absolutely nil in the dry season. The country rises rapidly on the south bank of the Asua to an equal elevation to that of Obbo; it is therefore the main drain of that portion of the country. Six days' march south of the Asua we arrived at Karuma Falls, at the ferry where Speke and Grant had crossed, and where they had left the river running from them due west.

Up to this point from Latooka the country had been very lovely, diversified with granite mountains, forests, prairies, and well watered with numerous rivulets, but very thinly populated. The natives perfectly naked, all equally ignorant of a Supreme Being, without any idea of worship, and free from even a vestige of superstition.

---

* The chief of Obbo—"Kachiba"—was the great magician of this country, but he confessed that his magic was of no avail against the flies which killed all cattle in his country. He was a renowned rain-maker, and he declared that he had a house full of thunder and lightning and rain quite at his own disposal for the crops, but he could do nothing with the flies who would assuredly kill my animals. Unfortunately his prophecy was true.

This old chief had 116 children living, and was a charmingly quaint old "pater familias." He told me that he was not naked from choice but from necessity, and he begged for clothes; not for mine fortunately, as I had none to give him, but for *my wife's*. He was quickly attired in lady's costume, to the great delight of his people and the admiration of his wives.

Like most Africans they were very averse to labour, and their time was passed in singing, dancing, drinking a fermented gruel, and committing raids upon their neighbours' cattle.

Many parts of the country had been utterly devastated by the slave traders; villages were reduced to ashes, and the population scared away, while hundreds were murdered or carried into slavery.

The last five days' march had been through uninhabited prairies; we now arrived at the Karuma Falls, and the passage of this portion of the Nile into the country of Unyoro was to introduce a totally distinct people.

After a day lost in obtaining permission to cross the river, a canoe was paddled from the Unyoro side, and we were ferried across about an hour after sunset. By the light of a fire the boatman showed me a string of blue beads that Speke had given him. It is impossible to describe the interest that so trifling an event occasioned, when in that wild country I came for the first time upon the track of my poor friend Speke.

On the following morning the natives positively refused to permit the passage of my men across the river, until they should receive orders from the king Kamrasi; we were thus cut off from the main party. The river was about 150 yards in width, boiling through a succession of rapids in its course west between high cliffs covered with bananas, and a great variety of foliage.

This was the first spot at which I had met with the banana.

For many days it was impossible to proceed south: the capital of Unyoro was about forty miles distant, and the king sent word that "big men were not in a hurry to pay visits, therefore I must wait." At length his majesty condescended to send for me, but we were twelve days marching forty-two miles, as spies were ordered to report upon our conduct daily; and we were systematically detained until messengers returned from Kamrasi.*

At length, after much patience exhausted, we arrived at the capital M'rooli, the residence of the king. We had marched from Karuma Falls parallel with the Nile due south, and at the junction of the Kafoor river in lat. 1° 37′ we were shown a few poor huts on a miserable swamp opposite the town, which were to form my camp.

---

* The people of this country were far superior in intelligence to any that I had seen. They were excellent smiths, using iron hammers instead of stones; they drew wire; made good pottery; they prepared superior tobacco; and manufactured very neat pipes; they worked fine braid of the plantain fibre, and cultivated their ground in a superior manner. Plantains were the staple food, and a variety of sweet potatoe, beans, and Indian corn. Their dress consisted of cloth made of the bark from a species of fig-tree; this tree was largely cultivated, and it was the custom for a newly-married man to plant a certain number in his garden, which were to be the tailors of the expected family.

At this spot the Nile was exceedingly sluggish, flowing through a marsh of papyrus rush. The Kafoor was also a deep river, having at that season no perceptible stream, and being about seventy yards wide. I was now within eighty miles of the first cradle of the river, the Victoria Lake. My course to the second-reported lake was west, but up to that moment I had been unable to obtain any information respecting its distance; the natives simply pointed to the west, and exclaimed "Magungo;" they appeared greatly amused, and ridiculed the idea of comparing its size to the Victoria, which they declared to be very inferior. This information was exceedingly interesting, as I had heard from the natives of Latooka, nearly twelve months previous, that there was water communication with the far south, as the cowrie shells were formerly brought in boats by white men* to a place called Magungo, which I imagined by their description to be on about the 2° N. lat. I now heard of the actual existence of the town Magungo. I had thus a direct clue to the lake.

After some days' delay, the great king appeared at the head of about a thousand men to pay me a formal visit; he was a tall, dignified man, remarkably clean and well dressed in bark cloth, arranged like the Roman toga. Throughout this country nudity was considered indecent, and both men and women were clean and attentive to their personal appearance; this sudden change from utter nudity and savagedom to decency is extraordinary, as on the north bank of the river at Karuma the natives are quite naked. The river in North lat. 2° 17′ is the boundary of the naked tribes.

I found the king very suspicious; he declared the lake to be six months' march from his capital; and for many days he amused himself by deceiving me upon all points, and begging for all that I had. His great fear was that I intended to go forward to Uganda to visit his enemy the King M'tesé, and to give him presents—thus, he was determined to fleece me completely, so as to render such a visit impossible. He surrounded me with spies, who reported to him all that they saw me use—thus, he asked me for my watch, sextant, compass, and a variety of objects that I had studiously kept from his view. The object most coveted was my sword; this I had refused to give him. I really was without hope of ever reaching the lake. Both I and my wife were martyrs to fever; my quinine was exhausted; my original escort was reduced to thirteen men; the conduct of the king was extremely suspicious and mistrustful; and the actual distance of the lake was unknown.

Fortune at length favoured me: I found a native trader in salt. The supply of salt for this and neighbouring countries was produced on the borders of the lake; and having won the trader's confidence by presents, he gave me the information that the lake was fifteen days' march from M'rooli for loaded men, but only ten days for a messenger. In my next interview with the king, I made him a most affectionate speech, and I offered to present him with my sword as a proof of my friendly intentions; at the same time I offered to slice through at one blow any shield he should produce, as a proof of its temper. This completely won his heart; his manner became quite cordial, and he said that he was quite assured of my sincerity, but that to prove our brotherhood we must drink each other's blood—a custom that must be gone through as a mutual exchange of vows. This was rather a strong dose. I told him that my countrymen considered the spilling of blood as a token of hostility; but to show him my good faith, I would order my head man to exchange blood with his greatest chief. At once he acceded to this proposal; the arms were bared and pricked with a sharp lance, and each licked the other's blood as it flowed from the vein. They requested that a gun might be fired to seal the compact, but the report occasioned a great panic among the crowd, who, in the rush to escape after the second barrel, tumbled over each other in the greatest confusion. This delighted the king, who was in the best humour possible; he promised to send me to the lake, and he immediately give me every information, confirming the report I had obtained from the salt dealer. I could not help asking him, "How so great a king could tell so great a lie?" as he had now confessed. Far from being ashamed, he burst out laughing, and replied, "Do you think I am such a fool as to tell strangers all that concerns my territory? I did not believe in your peaceful intentions until you gave up your sword. Now we have exchanged blood we are brothers. When would you like to start?" This looked like business. He immediately called one of his chiefs and a guide, and he ordered them to have porters and an escort ready on the morrow.

---

* The natives consider the Arabs as white men, as not being positively black.

He then told me all concerning the lake and the neighbouring countries, the whole of which information ultimately proved to be minutely correct, both by ocular examination and by the accounts I received from the natives.

The effect of the king's order that I was to be escorted to the lake was magical; the tongues of his subjects, that had hitherto been tied with the secrecy of freemasonry, were at once loosed, and all were ready to give information.

Kamrasi told me that the lake Luta N'zige was far larger than the Victoria Nyanza. The short road to Zanzibar he declared to be south-east of M'rooli on the east bank of the Victoria. He confirmed Speke and Grant's account that the Nile (or according to Speke the *Somerset river*) flowed out of the Victoria, and after turning due west from Karuma Falls it flowed for seven or eight days' march in a succession of rapids, and fell into the Luta N'zige. From its point of junction it almost immediately made its exit from the lake in a greatly increased volume, and continued as a navigable river to the north through the Koshi and Madi tribes for a distance unknown.

The Luta N'zige he described as extending south to Karagwé, forming the western frontier of that country, and from that point about 2° South lat., it turned to the west, its extent in that direction being unknown even to Rumanika, the King of Karagwé. Formerly this king Rumanika, being in communication with the ivory traders from Zanzibar, sent parties in all directions to purchase ivory with beads and brass coil bracelets and cowrie shells; sometimes Arabs accompanied his parties, and came down the lake Luta N'zige in large boats to Magungo, this latter place being the most northern limit of their journey.

Here was a corroboration of the information I had obtained twelve months ago. Magungo was the spot that I had always heard named in connection with the supply of cowrie shells. The route by which they arrived was now clearly established direct from Zanzibar. Nothing could be clearer than the geography of the country as given by the king. The lake Luta N'zige formed the western frontier of Unyoro, Uganda, and Karagwé, and was evidently the great basin of the Nile. To reach this great geographical point I was now determined.

After several days' delay the hour arrived to start. A crowd of about 300 grotesque warriors were to form my escort; these fellows were yelling and dancing, engaging in mock fights, and screaming like demons, being got up in Pandemonium style with horns upon their heads, false beards, tails of cows, and leopard skin mantles.

My slight escort of thirteen cowards were much scared at this exhibition.

At the last moment the king appeared to take leave, coupled with the mild request, that as he had agreed to send me to the lake, he expected me to make him a present of—my wife!!

We were surrounded by hundreds of his yelling savages, and this insolent demand was his ultimatum. I immediately drew a pistol and threatened to shoot him on the spot should he ever name the demand again, explaining to him that not all his men could save him should I touch the trigger. To my astonishment, at the very moment when I believed it to be the close of the last act, he said, "Don't be angry, I had not an idea you would be insulted. I should be very happy to give you a nice young wife of mine, and I thought you might have no objection to do the same. It is my custom to make any distinguished visitor a present of a pretty wife." Declining this kind offer, I insisted upon starting, and to make amends for his "faux pas," he immediately gave the order.

The march from M'rooli was full of misery; the rain poured in torrents; we were ill with fever; my wife fell senseless, struck by *coup de soleil*, and was carried in a litter insensible for seven days. We had no supplies, not even tea or coffee; no tent, nor in fact anything but blankets and ammunition, &c.; all had been left behind months ago for want of porters.

At length, after seventeen days' march from M'rooli, our flagging spirits were revived, the guide assured us that by noon on the following day we should reach the long-wished-for lake. Our route had been over park-like country, abounding in deep swampy hollows, overgrown with papyrus rush, the land increasing in elevation from M'rooli, that point being at the river level 4,061 feet, while the highest part of the route to the west was 4,562.

That night I hardly slept. For years I had striven to reach the "sources of the Nile." In my dreams I had always failed, but now the cup was at my very lips, and I was to *drink* at the mysterious fountain before another sun should set—at that great reservoir of nature that ever since creation had baffled all discovery.

I had hoped, and prayed, and striven through all kinds of difficulties, in sickness, starvation, and fatigue, to reach that hidden source; and when it had appeared impossible, I had determined to die upon the path rather than return defeated. Was it possible that it was so near? and that to-morrow I could say, "My work is accomplished?"

The 14th March. The sun had not risen when I was spurring my ox after my guide, who having been promised a double handful of beads on arrival at the lake, had caught the enthusiasm of the moment. The day broke beautifully clear, and having crossed a deep valley between the hills, we toiled up the opposite slope. I hurried to the summit; the glory of my prize burst suddenly upon me! There, like a sea of quicksilver, lay far beneath the grand expanse of water, a boundless sea horizon on the south and south-west glittering in the noon-day sun; and on the west, at 50 or 60 miles distance, blue mountains rising from the bosom of the lake to a height of some 7,000 feet. I cannot describe the feelings of that moment—here was the reward for all our labour—England had won the sources of the Nile. I was 1600 feet above the lake, and I looked down from the steep granite cliff upon those welcome waters, upon that vast reservoir which nourished Egypt and brought fertility where all was wilderness; upon that great source so long a mystery; that source of bounty and of blessing to millions of human beings. As an imperishable memorial of one loved and mourned for by our Queen, and lamented by every Englishman, I christened this great lake "The Albert N'yanza."

We commenced the descent of the steep zigzag pass, and after a toilsome walk of about two hours, weak with years of fever, but strengthened for the moment by success, we gained the level shore below the cliff. I rushed into the lake, and thirsty with heat and fatigue, with a heart full of gratitude, I drank deeply of the sources of the Nile.

The name of this spot was Vacovia, in N. lat. 1° 14'. The level of the lake was 2,720 feet above the sea. The shore was sandy, and the waves rolled up upon a clean shingle beach.

After eight days' detention, I obtained canoes and commenced a coasting voyage upon the lake towards the north, to search for the junction of the Nile.

After a voyage of thirteen days, I arrived at the Nile junction at Magungo, N. lat. 2° 16', the spot that I had heard of twelve months before, when I had but faint hopes of reaching it. Throughout the voyage from Vacovia the lake was deep and clear, the rocky cliffs in some parts rising to about 1,500 feet abruptly from the water. A few poor villages at long intervals were on the east shore, the scanty population engaged in fishing, and in preparing salt from the soil. They were extremely inhospitable, refusing in many cases to sell provisions.

At the Nile junction the lake had contracted to fifteen or twenty miles; the shores were no longer clean, but vast masses of reeds growing in deep water prevented the canoes from landing. Mountains had ceased on the eastern shore, giving place to hills about 500 feet high, which, instead of ascending abruptly from the lake like the mountains farther south, were five or six miles distant, descending in undulations to the water's edge.

The village of Magungo is about 250 feet above the lake, affording a fine view of the valley of the Nile, marked by a broad course of green reeds to the north, as it issues from the lake at a distance of from sixteen to twenty miles. Exactly below Magungo, the river that I had formerly crossed at Karuma, lat. 2° 17′, running due west, entered the Albert Lake in lat. 2° 16′, after a westerly course of about seventy miles.

Mallegga, on the west coast of the lake, is a large and powerful country governed by king Kajoro, who possesses boats sufficiently large to cross to the east shore. The Mallegga trade largely with Kamrasi, bringing ivory and finely-prepared skins and mantles in exchange for salt, brass-coil bracelets, cowrie shells, and beads, all of which, excepting salt, come from Zanzibar *viâ* Karagwé, there being no communication with the west coast of Africa.

The Albert Lake forms an immense basin, about 1500 feet below the adjacent country, receiving the entire drainage of extensive mountain ranges on the west, and of the Utumbi, Uganda, and Unyoro countries on the east, eventually receiving the great tributary from the Victoria lake at Magungo, its accumulated waters form the starting point of the main river, the White Nile.* From the junction at Magungo I went up the Somerset river in a canoe, the natives refusing to proceed farther north, owing to the hostile tribes of the Koshi and Madi. About ten miles from the junction, the channel contracted to about 250 yards in width, with little perceptible stream, very deep, and banked as usual with high reeds, the country undulating and wooded. About twenty miles from Magungo, my voyage suddenly terminated; for some time I had heard the roar of broken waters, and suddenly the great cataract of the Nile burst into view. The river, contracted from a grand stream of perhaps 200 yards width to a channel not exceeding fifty yards, rushes through a gap with amazing rapidity, and plunges at one leap into a deep basin below. This magnificent cataract I took the liberty of naming, after the distinguished President of the Royal Geographical Society, the "Murchison Falls." From that point I proceeded overland, parallel with the river, through Chopi to Karuma, to the identical spot where I had formerly crossed the river on first entering Unyoro.

---

* I was surprised to see, in the last 'Quarterly Review,' a doubt expressed as to the Albert N'yanza being the source or basin of the White Nile. To any one who knows the locality so intimately as I do, such a doubt appears simply absurd. I actually saw, from an elevation of about 250 feet, the river, at a distance of about eighteen miles, make its exit from the Albert N'yanza to the north in a broad valley of tall green rush, that rush being the characteristic of the White Nile. Both Kamrasi and the natives knew the river as well as we know the Thames, and they told me that it flowed through the Koshi and the Madi country. I subsequently met the river in those countries, and followed it down to Khartoum. Should any doubt still remain in minds obtuse, they will shortly contest that the Thames at Richmond is the river that flows under London Bridge.

The exploration being thus successfully terminated, the geography of the Nile resolves itself into comparative simplicity.

We will discard the name of "source," as it would be impossible to give preference to any individual stream among the many tributaries of the Nile.

Speke and Grant discovered the outlet from the Victoria Lake, a noble stream, named by Speke the Somerset river; that river flows into the northern end of the Albert Lake, which absorbs it without a perceptible current. The Albert Lake, 1500 feet below the general level of the country, has a length of about 260 geographical miles, and forms the only general reservoir, every river of that portion of equatorial Africa falling into that great depression; thus it receives each drop of water not only from the Victoria, but from a mountain range extending from the 2° South lat. to 2° 30′ North lat., and becomes the great basin of the Nile. From this great basin the Nile starts, a giant in its birth, receiving in its northern course only two *important* tributaries before it reaches Khartoum, the Asua, in lat. 3° 47′ (which is nearly dry for two months), and the Sobat, in lat. 9° 22′, both streams flowing, like *all* the great affluents of the Nile, from S.E. to N.W.

A rainfall of ten months' draining into the Albert Lake enables that great reservoir to send down to Egypt throughout the year a stream of sufficient volume to overcome the evaporation and absorption of the Nubian deserts. Without the White Nile not one drop of water from the Blue Nile would ever reach Egypt in the dry season, it would all be absorbed by the sand and evaportion, but in the month of June the Abyssinian rainy season floods the Blue Nile and the Atbara; thus the Albert Lake keeps up the volume through the dry season, when without it Egypt would cease to exist; and the rush of the Blue Nile and the Atbara in June, July, and August, added suddenly to the increased volume from the White Nile at that season, causes the inundations in Lower Egypt.

Thus is unravelled the whole secret of the Nile; the mystery that had baffled both ancient and modern times has yielded to the influence of England, and the honour belongs to her of having printed the first footsteps where all was untrodden, and of having brought to light all that since the world was created has remained in darkness.

I rejoice in having been permitted to be the humble instrument to share in this great work, and to have completed that discovery so nobly commenced by my friends and precursors, Captains Speke and Grant. As an African traveller, who can appreciate the difficulties they encountered and which they so gallantly overcame, I must be allowed to express my admiration of their great exploration, and render them the thanks of a fellow-explorer for an introduction I found when I struck upon their path, in the honourable name they had left behind them, a name that even savages can appreciate in the conduct of English gentlemen.

[S. B.]

WEEKLY EVENING MEETING,

Friday, February 2, 1866.

Sir Henry Holland, Bart. M.D. F.R.S. Vice-President, in the Chair.

The Earl Stanhope, F.R.S.

PRESIDENT OF THE SOCIETY OF ANTIQUARIES.

*On the Influence of Arabic Philosophy in Mediæval Europe.**

Few things in history are more striking than the encounter in divers parts of Western Europe, between the rising tide of Mahometan invasion and the settled races of Christendom. In Sicily, the Saracens achieved a short-lived conquest, one curious token of which may still be traced in the modern name given to Etna of Mongibello, a name made up of the Latin *Mons*, and the Arabic *Ghebel;* both words meaning the same, and conjoined together by the mingled races of the time. At the mouth of the Tiber, the victory of Pope Leo IV. over the Moslem marching on to Rome, even if it failed to be recorded by the Muse of History, would be rescued from oblivion by the Genius of Art, since, as you will remember, it forms the subject of one of Raphael's glorious frescoes in the Vatican. More to the northward, the Arab conquerors of Spain advancing into France had passed the Garonne, and well-nigh reached the Loire, when their progress was arrested and hurled back by Charles Martel. Then after centuries came the Crusades; then after centuries more, the final expulsion of the Moslem from Granada their last stronghold in western Europe. All this course of history is more or less familiar to my present hearers; but perhaps they may never have had occasion to observe the remarkable fact, not noticed indeed in many histories, that the race which showed itself the inferior in warlike prowess, gained the upper hand in some main points of intellectual influence. While the Moslem had for the most part to yield to the Christians on the fields of battle, they acquired an ascendant in the schools of philosophy.

---

* Abridged from his Lordship's discourse.

The intellectual or literary influence of the Arabs, a strange portent surely in an age of utter intolerance, and when it was unusual to allow merit of any kind in a misbeliever, may be mainly ascribed to two men of high renown, Avicenna and Averroes. Avicenna, whom, if we strove to be quite exact, we should call Aben Sina, flourished in Central Asia, and died in the year of Christ 1037. Averroes, or more precisely Aben Roshd, was born at Cordova, and died according to the best authorities in the year of our Lord 1198. Both are combined by Dante in two lines of his 'Inferno,' where he enumerates the principal pagan worthies. I will give you Dante's lines, as Mr. Cary renders them:

> "Orpheus I marked
>
> . . . .
>
> Galenus, Avicen, and him who made
> That commentary vast, Averroes."*

In like manner are they combined by Chaucer in his 'Prologue to the Canterbury Tales.' Much may be ascribed to the genius of these two men. Yet in the middle ages, when books were few and critics fewer still, we may suspect that the two names were sometimes used in a collective or representative sense. We may think, perhaps, that all the lore of Central Asia, was taken as summed up in Avicenna, as in Averroes all the lore of Mahometan Spain.

The works of Avicenna, as is believed, were brought to Europe at the time of the Crusades, in the form of a Latin translation, with which alone I have now to deal. This Latin version was put into type very soon after the discovery of printing, and there were several editions in the course of the sixteenth century, above all at Padua and Venice. Most of his treatises relate to his profession of medicine; but there are some of a more general nature, and bearing on the general questions of philosophy.

The principal work of Avicenna is a so-called 'Canon,' in five books, on the 'Art of Healing.' During several centuries, this canon may be said to have reigned supreme in the Christian schools of medicine. M. Jourdain, writing in the 'Biographie Universelle,' about the year 1811, observes, that scarce a century back—in the last years, therefore, of Louis XIV.—the Canon of Avicenna was still the text-book in both the Universities of Montpellier and Louvain. At present it might be difficult to name any book which is more entirely unread, or has fallen into more complete neglect. One of the last writers who seems to have paid it attention is Dr. Freind, the famous physician in the time of George I., and he speaks of it in by no means favourable terms. "In general," says Dr. Freind, "Avicenna seems to be fond of multiplying the signs of distemper without any reason; he often, indeed, sets down some for essential symptoms, which arise merely by accident, and have no immediate connection with the primary disease."

---

* "Averroes che 'l gran comento feo."

Of the numerous remedies which the works of Avicenna recommend, many seem in a high degree fanciful; yet some, perhaps, though we are unconscious that they rest on his authority, have survived to the present time. Thus, when corals are still placed in the mouths of infant children, in preference to ivory or any other hard substance, we may probably derive that practice from the words of Avicenna, where he declares that there is an occult or mysterious virtue in coral, which makes it the highest of all remedies for the comfort of the gums. As is said in the quaint and semi-barbarous Latin of his translated work, *Summus est corallus in confortatione gingivæ.** In other passages, we find him share the common belief of his age as to the planetary influences. "If," he says, "these stars, which are called unpropitious, are in the ascendant, they bode decay to animated beings; but if those which are called propitious, then the signification is health."† In like manner, he considers the efficacy of remedies as dependent on the wane or the increase of the moon.

Another authority on the healing art held in high estimation all through the Middle Ages was the school of medicine at Salerno. That school was, as Gibbon expresses it, "the legitimate offspring of the Saracens." It was trained by Arabic professors; it was taught from Arabic books. Towards the year of Christ 1100, a curious little volume was compiled by John of Milan, one of the physicians of this school, and was dedicated to the King of England, but to which is not quite clear:

Anglorum Regi scribit Schola tota Salerni.

This volume embodies some of the most approved maxims for health, in Latin verses of the kind called Leonine, that is, in rhyme according to the favourite fashion of the Middle Ages. Thus put into a popular form, these maxims appear to have enjoyed a high popularity until a recent period. They were annotated with great care by Arnald de Villanova; and to the edition of 1649 is prefixed an elaborate preface by Zacharias Sylvius, a physician of Rotterdam. The second chapter of his preface opens as follows:—"There is scarce any physician in Holland but has frequently in his mouth the verses of the Salerno school, or who fails to quote them on every occasion." This, you see, is little more than two centuries ago. Indeed, as I imagine, no doubt at all can exist that all through the Middle Ages the Arabic School of Medicine was greatly superior to the Latin.

---

* 'Op. Medecinæ,' vol. i., p. 287. Ed. 1608.

† 'Op.,' vol. ii., p. 379.

. . . .

Reverting to Avicenna, not in his character of physician but of a philosopher, we shall find that he is disposed to distinguish between a higher and a lower spirit or intelligence in man; that is, as I apprehend it, between the life and the soul. He considers the vital spirit not so much as one, but rather, as the aggregate of the different vital powers, taking, after Galen, the brain as the seat of thought, the heart as the seat of courage and other emotions, and the liver as the seat of the animal exertions or powers. In general, Avicenna seems only too ready to assign causes, sometimes with little discretion, for the various phenomena of created beings. But in some passages he shows a deeper humility and a truer wisdom. "This," he says of one mysterious process, "is among the secrets known to God alone. All glory then be to God, who is the King of all, the source of truth and praise, the aim of our benedictions, and the first of all things that have being."[*] Surely such words as these ought to have exempted Avicenna from the vague charges of impiety and atheism, which some writers of the Middle Ages, as William of Auvergne, are, I see, quoted, as having with much presumption brought against him.

The views of Avicenna on our spiritual nature are, however, best deduced from an Essay, to which, even in the Latin version, there is given the title of *Almahad.*[†] *Almahad*, then, is the condition or the place to which the soul of man will take its flight after his decease. The supreme happiness to which the soul aspires has here, he says, for obstacle, the body. Therefore, in another life, its felicity will be in its separation and enfranchisement from its earthly trammels. Its reward would lie in the nearer contemplation of the Almighty and of those sublime essences which adore him. On the other hand, its punishment would lie in its exile and its distance from them. Some souls, however, which though perfect in speculation were not perfect in deeds, will be consigned to an intermediate sphere—the *Berzach* or purgatory—a mean between felicity and suffering. Thus it will be seen that the religious aspirations of Avicenna, although a Mahometan in creed, have none of that material grossness which is commonly ascribed to the paradise of Mahomet. On the contrary, adopting as they do the doctrine of a purgatory, they appear in close accordance with the teaching of Catholic theologians in that age.

Before I pass from Avicenna, I may mention another instance which has but lately come to light, of the favour which he found in the West. The present Dean of St. Paul's has printed for the Philobiblon Society, a catalogue of the books of Richard de Gravesend,

---

[*] 'Op.,' vol. i., p. 924.

[†] It is a book of some rarity; but it may be read, as I have read it, in the Library of the British Museum.

Bishop of London. It bears date the year of our Lord 1303, and "this I apprehend," adds the Dean, "is the earliest priced catalogue known." Now one of the entries in it is *Liber Avicennæ*, priced at 5*l.*, which, according to the Dean's calculation, is equivalent to about 150*l.* of our present money. A strong proof of the estimation in which Avicenna was held at that period, even among the prelates of another creed.

I come now to Averroes, whose writings are far more voluminous than those of Avicenna, and had also an influence far more extensive and deep-rooted. Like those of his predecessor, they were known to Christian Europe only through the medium of a Latin translation. Of late years, however, the original sources also appear to have been carefully explored. Special notice is due to the learned and able work of M. Ernest Renan, which in its revised and completed form appeared in 1861. . . . . It gives both the life and the doctrines of Averroes far more fully than within the limits of this lecture I could hope or attempt to do.

In philosophy, Averroes professed himself a follower of Aristotle, whose works, having them before him in an Arabic version of older date, he made the subject of a long and laborious commentary. . . . The "doctrine of Aristotle," he says, "is the Sovereign Truth. The researches of Aristotle mark the limits of the human understanding, and there can be no dissent from anything that he has stated. The only doubt would be as to the right interpretation of his words, or as to the logical consequences to be deduced from them."*

But in noting this homage to the Stagyrite, we should bear in mind that the other wise men of the East in the Middle Ages were nearly agreed on this point with Averroes. All of them were disposed to acknowledge Aristotle as their chief and master. How wonderful, I may say in passing, is this proof of the supremacy of the old Greek race as shown in the instance of two men who stood to each other in the relation of pupil and preceptor. The pupil, Alexander the Great, by dint of military genius, subjugates Asia! The preceptor, Aristotle, after the lapse of centuries, and solely by the force of intellect, holds Asia in thrall again!

In considering, however, the relation of the Arabic philosophers to those of Ancient Greece, there are at the outset two remarks that present themselves. It is certain that in some places Averroes ascribes to Aristotle doctrines which Aristotle never held. Divers critics—as Bayle, in his Dictionary, draws them out in array—suppose that these errors of Averroes may have arisen from the faulty Arabic version that lay before him. But as it seems to me there is another conjecture at least equally probable. Some of the speculations of Averroes, as will presently be seen, were extremely bold. They greatly displeased the leading Muftis. They exposed him to no small amount of obloquy and persecution in his latter years. What more natural, then, than that Averroes and his followers should endeavour to anticipate attacks like these, and bring forward their tenets with the great name of Aristotle as their shield. . . . . .

---

* See these passages in Renan, p. 55.

Avicenna and Averroes were, I think, exactly on a level in their study of Greek. Both could read it only by means of an Arabic translation; both applied themselves mainly to the same two authors, Aristotle and Galen. But there was this difference between them. Avicenna desired to hold the balance even between his two Greeks. Averroes on the other hand, in his almost idolatry for Aristotle, laboured hard whenever Aristotle and Galen may differ to reconcile their views; but if reconcilement seemed to be impossible, he then invariably sided with the Stagyrite. . . .

The instance of Averroes is another proof that a prophet hath no honour in his own country. His doctrine was of little or no mark among the Moslem communities. During his lifetime, indeed, as we have seen, it excited sufficient notice to draw upon him a considerable degree of religious persecution. But after his decease it was speedily forgotten. Thus, in his own Mahometan sphere, he left no followers, and he founded no school. It is shown by M. Renan, who gives the particular examples, that this author of eleven folio volumes as since published in a Latin version, is not once mentioned even by name in several lists of Mahometan philosophers and other worthies, which were drawn up in the ensuing centuries at Cairo and other main seats of Oriental learning.

The renown of Averroes is therefore entirely dependent on the great and extraordinary favour which his tenets found among the learned men, both Jews and Christians, in Western Europe. And first as to the Jews. When we consider how that people was persecuted and down-trodden all through the Middle Ages; how, without any fixed country of their own, they were driven to and fro from place to place to escape the bigot and the spoiler, we must be struck at the indomitable spirit which enabled their chief men, even amidst these heavy trials, still to apply themselves to the pursuit of knowledge. A list is given of eminent Jewish scholars from Maimonides downwards, who, in their study of philosophy, have eagerly applied themselves to Averroes, translating his principal treatises from Arabic into Hebrew, and adopting as their own many of his tenets. Of these Jewish works upon points of philosophy, apart from the teaching of Averroes, the latest in point of time, and also, I should apprehend, by far the highest in point of ability, is that most ingenious dialogue in the Platonic manner, the 'Phaedo' of Moses Mendelsohn. . . . .

Next, as to the Christian writers. The earliest of these who appears to have translated Averroes, or brought him into note in Western Europe, was our own countryman, the reputed wizard, Michael Scott. He is mentioned by Roger Bacon as having first brought forward certain books of Aristotle, with certain learned commentaries; and we collect from other sources, that these commentaries were no other than those of Averroes. Through him, adds Roger

Bacon, the philosophy of Aristotle was glorified in the Latin sphere. *Magnificata est Aristotelis philosophia apud Latinos.* This, he says, was in the year of Christ 1230, that is little more than thirty years from the death of Averroes.

Seen by the light of modern science, some of the deductions of Michael Scott from his Arabic source, are not a little fantastic. They seem the stranger when, as in some cases, invested with the forms of the Aristotelian logic—forms which at one time were considered as affording one main security for the demonstration of truth. Here is a fragment, the Latin original of which is still preserved at Paris, in the Library of the Sorbonne :—"The firmament of heaven is round, and all that is round is perfect, therefore the firmament of heaven is perfect. But everything that is perfect is free from motion, because it can want or seek no good gift which it has not already, and the firmament of heaven is perfect; therefore, the firmament of heaven also is free from motion." Accordingly, as Michael Scott goes on to say, any danger to the great celestial system would lie in the possible motion of its parts; and this, he adds, is what Averroes teaches.

. . . .

Hermannus Alemannus, or the German, is mentioned as the next in order of the translators of Averroes into Latin. He also studied at Toledo, and availed himself of Jews as his Arabic interpreters, in the version which he made. The doctrine of Averroes being thus made known to the learned men of France and Italy, it speedily raised up powerful defenders, and no less powerful opponents. Chief of the latter, as taking their stand on the theological fastness, were, in the next age, Albert, surnamed the Great, and Thomas Aquinas.

But you will naturally ask, What then was that doctrine on the one hand so extensively adopted; on the other hand so keenly assailed? I here come, then, to that one distinctive tenet which has been the main source of Averroes's fame. He maintained as the true Aristotelian doctrine that there is an *Anima Mundi*—a soul of the world. He held that there exists one common intelligence which is immaterial and immortal, and which still preserves its numerical unity, though disseminated among the many millions of mankind. It might thus be put, perhaps, that a spark of the intellectual flame flies forth to join each human being at its birth, and that at the decease of that human being it flies back, to be again absorbed in the central intelligence. I must observe, however, that it is by no means easy to describe, with even approximate precision, a doctrine, which was much clouded over by the animosity of its opponents, and still more frequently obscured by the fears of its defenders. Several of its points were not I think expressed in plain terms, and were rather left to be inferred. One of the necessary deductions arising from it is stated as follows, by Mr. Hallam, in the first volume of his 'Literary History':—"If the human soul, as an universal, possess an objective reality, it must surely be intelligent; and being such, it may seem no extravagant hypothesis, though one incapable of that demonstration we now require n philosophy, to suppose that it acts upon the subordinate intelligences of the same species, and receives impressions from them."

Even from so slight a sketch of this doctrine, we may readily see how it could happen that a long and stubborn controversy arose whether or not it admitted the immortality of the soul. The disciples of Averroes maintained that it did; his opponents urged that it did not. And certainly there is something to be alleged on both sides. If the soul, on quitting its tenement of clay, becomes absorbed into a superior but still kindred intelligence, it cannot be said to perish; but on the other hand, if it is to preserve no self-consciousness nor personal dentity, then to say the least, there is a wide departure from the idea of an immortal soul as commonly understood or received.

It is not to be supposed that this doctrine of Averroes was understood in the same manner by all his disciples. On the contrary, there were numerous subtleties and subdivisions, according as learned men, who were attracted towards it, laboured from time to time, and with more or less success, to bring it into harmony with the tenets of evealed religion. Thus it might be supposed that the spark of the *Anima Mundi*, which, according to Averroes, is sent to animate each human being, need not at the death of that human being immediately and of course rejoin the central essence, but may be destined, in punishment or in reward, first to pass through either higher or lower phases of existence. Such a view of the case would, therefore, not be rreconcilable with the doctrine of future retribution for the good or evil deeds of the present life, though evidently falling short of the orthodox dogma which teaches an eternity of acceptance or of condemnation.

It was not merely on the soul of man that Averroes formed his peculations. I have already found occasion to give you some of his views on the celestial bodies, as deduced by Michael Scott. In his own writings these views are still more clearly expounded. He ooked upon the heavens as forming together a series of animated beings, whose various orbs represent the members essential to life, and whose main mover is to them what in the human frame the heart is to he limbs. Each of these orbs, according to Averroes, has self-conciousness, and knows also what is passing in the orbs inferior to tself. The highest sphere of all, has therefore a full knowledge of whatever is passing in the universe. You will see at once how closely his system connects itself with the idea of a central intelligence.

And yet, notwithstanding dreams like these, in which many men of genius besides Averroes have at times indulged, it may I think be said with truth that this Arabian, far from being behind his contemporaries n this subject of astronomy, was greatly in advance of them. All at hat time clung with undoubting faith to the astronomical system of Ptolemy.

"Cycle and epicycle, orb on orb."

The system of Ptolemy is well known. He explained the divers movements of the stars by the supposition of crystalline spheres without any stint of numbers, so that, as Fontenelle long afterwards observed, crystalline spheres cost him nothing, and he designed a new one at each fresh occasion that arose. On this point Averroes, greatly to his honour, forsook his Grecian guide. There is a remarkable passage upon it in the twelfth book, chapter 4 (not the thirteenth book, chapter 8, according to the erroneous reference of M. Renan), of his 'Commentary on Aristotle's Metaphysics.' He gives arguments against Ptolemy's whole system of epicycles and eccentrics, which he declares to be impossible. "Nature," he adds, "does nothing in vain, and it is unworthy a philosopher to suppose that she employs two instruments when a single one would effect the object in view. It is therefore needful that there should be a renewed investigation of that genuine astronomy, which rests on natural foundations. In my youth, I hoped that such an investigation might be made by myself. Now, in my old age, I despair of it. But still my observations may stir up some other man to pursue these inquiries in my place."

This wish, as you well know, was fully accomplished, but not until centuries after Averroes had ceased to be.

The doctrines of Averroes then, taken as a further development of the doctrines of Aristotle, provoked much keen discussion in the Middle Ages; but that discussion was by no means always uniform; on the contrary, very different phases of it may be traced as it proceeded. Under the Emperors of the House of Suabia, engaged as they were in ceaseless conflict with the ecclesiastical powers, a sceptical spirit was afloat. Indeed, it has been observed, that in this respect, Italy during the thirteenth century bore a striking resemblance to France during the eighteenth. With the sceptics then of the thirteenth century, the disciples of Averroes came to be allied. . . .

But another phase of opinion was near at hand. Not only the race of the Suabian princes but their traditions having passed away, the sceptical spirit which had been cherished at their Court subsided as rapidly as it rose. The followers of Averroes were no longer regarded as of course enemies of the Church. No stronger proof of this can be given than that for a long period they held supremacy in the Catholic University of Padua. The faith in Averroes came to mean faith in his Commentary; that is, to regard him as the best and most trustworthy of all expounders of Aristotle. In like manner, the Averroist tenet of a common intelligence was frittered down until it came to little more than the identity of spiritual principles and powers in the divers souls of men; a dogma to which, as thus modified, no reasonable objection could be made. Still, however, we are to understand that the doctrines of Averroes, in their primitive sense, continued to be held and even taught in private by no small number of persons.

In the mitigated form which Averroism had now assumed, or at least professed, it might still have continued during many years to bear sway in Northern Italy. But at the commencement of the sixteenth century, there came that great stir and upheaving of the human intellect which produced Luther, and in its results tore Christendom asunder. It was at work even earlier in Italy than in central Europe, but embraced other topics besides those of the Reformation, since even so fundamental a doctrine as the immortality of the soul was in some quarters frequently denied. Then, as had already happened in the thirteenth century, the sceptics, if they were not joined by the Averroists, endeavoured at least to shelter themselves under their name and authority. Then, as was natural and reasonable, the theologians took alarm. A council was held at the Lateran, and in December, 1512, there was issued a Pontifical Bull, joining in one common condemnation the men who denied the immortality of the soul, and the men who maintained the *Anima Mundi*. And in this manner came forth at last an authoritative decision of the Roman Catholic Church against, in one form or another, the favourite and distinctive tenet of Averroes.

In my view of the case, however, the decline of Averroism may be traced to a different cause, and to a somewhat earlier period. Its decline, as I conceive, dates from the 4th of April, 1497, on which day a learned man, whose name is given, rose in his professorial chair at Padua, to lecture upon Aristotle, then first from the original Greek.* Then fell Averroes, never more to rise. For let it be remembered what was in truth the Commentary of Averroes. It was derived by him from a faulty Arabic version, and it was transmitted by his disciples to the Western races in a faulty Latin version. How could a Commentary thus exposed to a twofold cycle of errors in translation continue to hold its ground against other commentaries founded in the living, the authoritative, Greek?

It is worthy of note, however, that from the time of the Lateran Council, the Church authorities looked with a suspicious eye, not merely as was natural on the Commentary of Averroes, but even in some degree on the original works of Aristotle. . . .

To conclude; there is only one other observation which I have to make. I should wish you to notice that the subject which I have chosen does not imply any knowledge of the original Arabic sources. If it did I could not have undertaken it without the most extreme presumption. But in truth the subject which I announced, and which accordingly I have now discussed, is solely the "influence" of the Arabic philosophy—its influence in Mediæval Europe. Now, as I have already had occasion to apprise you, that influence was exerted in every case, and quite exclusively, by means of Latin translations. It is, therefore, only with these translations or with the testimonies to them, that my appointed subject has led me to deal, or that I have dealt, in the address which at this point I have the honour to conclude.

---

* His name was Nicholas Leonicus Thomaeus. See Renan, p. 385.

GENERAL MONTHLY MEETING,

Monday, February 5, 1866.

The **Earl Percy**, Vice-President, in the Chair.

The Earl Spencer, K.G.
Joseph Brandeis, Esq.
Charles Lucas, Esq.
Frederick Mouat, M.D.
Abraham Walter Paulton, Esq.

were *elected* Members of the Royal Institution.

Protheroe Smith, M.D.

was *admitted* a Member of the Royal Institution.

The Special Thanks of the Members were returned to Mrs. **Barlow**, for her Fifth Annual Donation of Five Guineas, and to the Donors of the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151):—

John Peter Gassiot, Esq. (*3rd annual donation*) .	£20	0	0
The Rev. John Barlow (*3rd donation*) . . .	10	0	0
Samuel Gaskell, Esq.	30	0	0
Thomas Williams Helps, Esq.	10	0	0
J. Carrick Moore, Esq. (*3rd annual donation*) .	10	0	0
John Parnell, Esq.	10	0	0
Professor Tyndall (*2nd donation*)	20	0	0

The Secretary announced the decease of Mr. Charles Anderson (Assistant in the Laboratory since 1832), on the 8th of January last.

The **Presents** received since the last Meeting were laid on the table, and the thanks of the Members returned for the same, viz.:—

FROM

British Museum Trustees—Catalogue of Mammalia, &c., of Nepaul. 2nd ed. 1863.
Catalogue of Fishes. Vols. IV. and V. 8vo. 1862–4.
List of Lepidopterous Insects: Nos. 24–34. 12mo. 1862–5.
Catalogue of Coleoptera of the Canaries. 8vo. 1864.
Catalogue of Amphipodous Crustacea. 8vo. 1863.
Catalogue of British Birds. 8vo. 1863.
Catalogue of British Parasitical Worms. 8vo. 1865.
Actuaries, Institute of—Assurance Magazine, No. 62. 8vo. 1866.
American Philosophical Society—Transactions, Vol. XIII. Part 2. 4to. 1865.
Proceedings, Nos. 73, 74. 8vo. 1865.

Asiatic Society of Bengal—Journal, Nos. 128, 129. 8vo. 1865.
Astronomical Society, Royal—Monthly Notices, 1865–6. Nos. 1, 2. 8vo.
Bavarian Academy of Science, Royal—Sitzungsberichte, 1865. Band II. 1–2. 8vo.
Annalen der königlichen Sternwarte, Band XIII. und XIV. 8vo. 1864–5.
Liebig, J. von, Induction und Deduction. (K 92) 8vo. 1865.
Nägeli, C. Enstehung und Begriff der Naturhistorischen Art. (K 92) 8vo. 1865.
Bombay Geographical Society—Transactions, Vol. XVII. 8vo. 1865.
Bourke, The Lady Susan Georgiana—Inuentaires de la Royne Descosse Douairière de France. Catalogue of the Jewels, Dresses, Furniture, Books, and Paintings of Mary Queen of Scots, 1566-1569. [Edited by the Marquess of Dalhousie, for the Bannatyne Club.] 4to. 1863.
Chemical Society—Journal for Nov. Dec. 1865. 8vo.
Churchill, Messrs.—Quarterly Journal of Science, No. 9. 8vo. 1866.
Cornwall Polytechnic Society—Annual Report, 1864. 8vo. 1865.
Editors—American Journal of Science, Nov. 1865. 8vo.
Artizan for Dec. 1865; Jan. 1866. 4to.
Athenæum for Dec. 1865; Jan. 1866. 4to.
Chemical News for Dec. 1865; Jan. 1866. 4to.
Engineer for Dec. 1865; Jan. 1866. fol.
Horological Journal for Dec. 1865; Jan. 1866. 8vo.
Journal of Gas-Lighting for Dec. 1865; Jan. 1866. 4to.
Mechanics' Magazine for Dec. 1865; Jan. 1866. 8vo.
Pharmaceutical Journal for Dec. 1865; Jan. 1866.
Practical Mechanics' Journal for Dec. 1865; Jan. 1866. 4to.
Faraday, Professor, D.C.L. F.R.S.—M. F. Hugueny, Recherches Expérimentales sur la Dureté des Corps. 8vo. 1865.
Recherches sur la Composition Chimique des Eaux Potables. 8vo. 1865.
Memorie della Società Italiana delle Scienze di Modena. Serie 2. Tomo I. 4to. 1862.
Franklin Institute—Journal, Nos. 477, 478, 479, 480. 8vo. 1865.
Geographical Society, Royal—Proceedings, Vol. X. No. 1. 8vo. 1865.
Geological Institute, Royal, Vienna—Jahrbuch, Band XV. No. 2. 4to. 1865.
Horticultural Society, Royal—Proceedings, 1865. No. 9. 8vo.
Journal, Vol. I. No. 1. 1866. 8vo.
Irish Academy, Royal—Transactions, Vol. XXIV. Six Parts. 4to. 1864–5.
Proceedings, Vol. IX. Part 1. 8vo. 1865.
Linnean Society—Journal and Proceedings, Zoology, Nos. 31, 32. 8vo. 1865.
Lloyd, W. Watkiss, Esq. M.R.I. (the Author)—Christianity in the Cartoons, referred to Artistic Treatment and Historic Fact. 8vo. 1865.
Mechanical Engineers' Institution, Birmingham—Proceedings, Aug. 1865. 8vo.
Meteorological Society, British—Proceedings, No. 21. 8vo. 1866.
Northumberland, The Duke of—Memoir of a Survey of the Eastern Branch of the Watling Street: with Plans by Henry MacLauchlin. 8vo and fol. 1864.
Peters, William, Esq. (the Author)—Difference between Square and Superficial Measurement. (O 14) 16to. 1865.
Photographic Society—Journal, No. 165. 8vo. 1865.
Royal Society of London—Proceedings, Nos. 77, 78, 79, 80. 8vo. 1865.
Philosophical Transactions for 1865, Vol. CLV. Part 2. 4to. 1865.
Observations Météorologiques faites à Nijné-Taguilsk. 1864. 8vo.
Scottish Society of Arts, Royal—Transactions, Vol. VII. Part 1. 8vo. 1865.
Squire, Peter, Esq. F.L.S. M.R.I. (the Author)—Pharmacopœias of Thirteen of the London Hospitals, arranged for Comparison. 16to. 1863.
Statistical Society of London—Journal, Vol. XXVIII. Part 4. 8vo. 1865.
St. Petersburg, Imperial Academy of Science—Mémoires, VII^{e} Série. Tome V. No 1; Tome VII. et Tome VIII. 4to. 1862-5.
Bulletins, Tome VII. N^{o} 12–36; Tome VIII. 4to. 1864–5.
Swanwick, Miss Anna, M.R.I. (the Author)—The Agamemnon of Choephori, and Eumenides of Æschylus, translated into English Verse. 16to. 1865.
United Service Institution, Royal—Journal, No. XXXVI. 8vo. 1865.

Vereins zur Beförderung des Gewerbsfleisses in Preussen—Verhandlungen, Mai–Aug. 1865. 4to.

Wedgwood, Hensleigh, Esq. M.R.I. (the Author)—The Origin of Language. 16to. 1866.

WEEKLY EVENING MEETING,

Friday, February 9, 1866.

Sir Henry Holland, Bart., M.D. D.C.L. F.R.S. President, in the Chair.

Archibald Smith, Esq. M.A. F.R.S.

On the Deviation of the Compass in Iron Ships.

The deviation of the compass is a subject of great and increasing importance, owing to the great and increasing amount of iron used in the construction of vessels, and the consequent increase in the amount of the deviation and in the apparent irregularity of its laws.

On the present occasion it will be necessary for me to omit altogether some of the most important and most interesting parts of the subject—*viz.* 1st, the mathematical part, including algebraical formulæ. arithmetical processes, and graphic constructions of great interest and utility; and, 2ndly, the numerical results for different ships and classes of ships which have been obtained from the reduction and discussion of observations made in a large number of ships of the Royal Navy. I must confine myself to an attempt to explain the principles on which the forces which cause the deviation act, and the principles on which the deviations produced can be reduced to law. and to stating generally what has been accomplished and what remains to be accomplished.

General Considerations.

1. A magnet is a bar of steel. the ends of which have opposite properties. They are generally marked N. and S. (north and south), but to avoid the confusion which would be occasioned by speaking of the magnetism of the north end of the needle or of the north end of the earth as south magnetism, it is convenient to distinguish them as *red* and *blue* (which may be remembered from R occurring in North and U occurring in South).

The property is that the red end of one magnet attracts the blue end and repels the red end of another magnet, and *vice versâ*.

If we lay two magnets at a little distance in the same line with unlike poles turned to each other. and lay a soft iron rod in the interval between them, the soft iron rod will be magnetized by induction: the end next the blue pole of one magnet will become red. the end next the red end of the other magnet will become blue. If we turn the rod about its centre. it will gradually lose its magnetism. till, when at right angles to the line of magnetization, it will be neutral, and if we turn it further, it will become magnetized in the opposite way.

The earth is a magnet, having a blue pole in latitude 70° N., long. 96° W., and a red pole in lat. 75° S., and long. 154° E.

The direction of the magnetic force in London at present is the same as if there were a blue pole 20½° to the west of north, and 68° below the horizon, and a red pole 20½° to the east of south, and 68° above the horizon. This direction is called the line of force, or the line of "dip." If we hold a soft iron rod in the line of dip, it becomes instantly magnetised, the north or lower end becoming red, the south or upper end becoming blue. If we hold the rod vertically, the lower end will still be red, but of less intensity, the upper end blue, also of less intensity. If we hold the rod horizontally north and south, the north end will be red, but of still lower intensity, the south end blue, also of lower intensity. If we now turn the rod in the same horizontal plane, its magnetism will diminish till it becomes east and west, when it will be neutral, and if we turn it still further the magnetism will be reversed; the amount of the changes will be greatly increased by hammering the rod in each position. In a rod which I used, the effect was increased by hammering from 12 to 80, or between six and sevenfold. If the iron had been perfectly soft, it results from the experiments of Weber and Thalen that the effect would have been about 36.

A sphere of soft iron will be magnetized in the same way however held. The diameter in the line of dip will be the axis of magnetism, and the lower and north half of the surface will be red, the upper and south half blue.

In bodies of any other shape the effects will be similar, though less regular, if the shape be irregular.

In an iron ship, on the stocks, intense magnetism is developed by the process of hammering; red magnetism being developed in the part of the ship which is below and towards the north, and blue magnetism in the part which is above and towards the north.

As the usual position of the compass is near the stern, it follows that in the case of ships built head north, the compass is in a position where there is an intense blue magnetism drawing the north end of the compass strongly to the stern and downwards, and generally producing a very large deviation, besides a large heeling error. In such ships it is of importance to have a standard compass well forward.

In ships built head south, there will generally be less deviation and little heeling error in the usual position of the compass.

In ships built east and west the amount of deviation is generally small, but is less regular than in ships built head south.

Theoretical Representation of the Deviation.

If we place a magnet before the compass with its blue end turned to the compass, it will draw the north end of the needle to the ship's head, and as the ship turns round there will be, in the first or eastern semicircle, a deviation of the north point of the compass to the right hand or east, in the second or western semicircle, a deviation to the left hand or west. This would produce one part of what is called the "semicircular" deviation.

If we place a soft iron rod vertically in front of the compass, with its upper end at the level of the compass, this end, which will be blue, will attract the north end of the needle, and produce a deviation of exactly the same kind as the magnet which we have considered. It will, therefore, simply increase the semicircular deviation caused by the first magnet. If the red end of the imaginary magnet, or the lower end of the imaginary rod, be nearest the compass, or if the magnet or rod be abaft the compass, an effect of the same kind, but in an opposite direction, will be produced.

A magnet to starboard or port of the compass will produce a similar effect, except that a deviation of one kind will be produced when the ship's head is on the north semicircle, and of the other kind when on the south semicircle. This is the other part of the "semicircular" deviation.

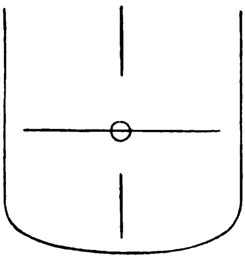
The effect of the two magnets and the one iron rod, which we have considered, make up the whole of what is called the "semicircular" deviation.

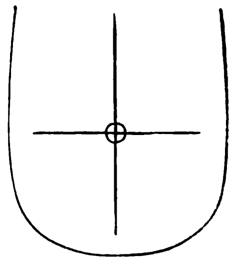
If we lay a horizontal soft iron rod in front of and directed to the compass, it will easily be seen that when the ship's head is N., S., E. or W. it produces no deviation. When N.E. and S.W. it produces a deviation to the right hand or E., and when S.E. or N.W. a deviation to the left hand or W., it therefore produces what is called the "quadrantal" deviation.

A horizontal soft iron rod directed to the compass, but placed to the starboard or port, will produce an effect of exactly the opposite kind, and would correct that produced by the first rod; but if the second rod, instead of being on one side, passes, as it were, through the compass, it will produce exactly the same effect as the first rod. The two rods will then conspire to produce the quadrantal deviation.

A quadrantal deviation of the same kind will be produced if the first rod instead of being on one side of the compass passes through it, provided always that its force is less than that of the transverse rod.

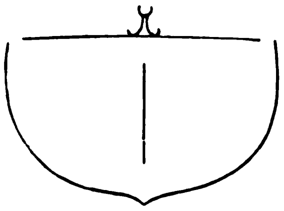
In almost all known ships the quadrantal deviation is what would be produced by two such rods, *i.e.* rods of one or other of the following types—

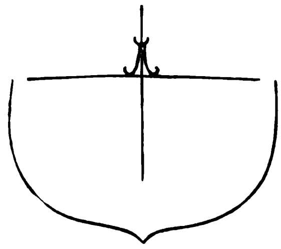




Between the two types there is an important difference, which will be easily traced out. The second type would always diminish the directive force of the needle, while the first type would increase or diminish it according as the force of the fore and aft rods is greater or less than that of the transverse rod.

The effect of the magnetism when a ship heels over may be seen by the diagrams which follow.





It will easily be seen that as the ship heels over, the upper end of the transverse rod becomes blue and attracts the north end of the needle to windward, and also that the upper end of the vertical rod which is below in the first figure, by the effect of heeling, is moved to windward, and draws the north end of the needle to windward, and increases the heeling error caused by the transverse beam, while in the second figure it is moved to leeward and counteracts the heeling error caused by the transverse iron.

Compasses on the upper decks of iron ships, particularly if they have been built head north, are of the first type, and there is generally a large heeling error to windward. Compasses on the main deck, and particularly of iron-plated ships, are generally of the second type, and the heeling error is often to leeward.

The amount of error in each case may be easily determined by observations of vertical force, and by separating the two parts of the quadrantal deviation, without actually heeling the ship.

The magnets and soft iron rods we have imagined must not be considered as mere possible cases, but as representing truly the actual case in all ships. They are in fact the physical interpretation of Poisson's general formulæ for the action of induced magnetism, which interpreted amount to this, that the effect of the iron of any body, however irregular, on a magnetic particle, is exactly the same as that of nine soft iron rods and three magnets. When the iron is symmetrically distributed, as in a ship, the rods are reduced five in number, *viz.* the four we have considered, and a fifth lying fore and aft, with one end below the compass, which would make the heeling error greater or less with the ship's head north than it is with the ship's head south, but this is not an effect of much importance.

Effect in particular Ships.

In wooden ships the semicircular deviation is represented by the effect of a single vertical rod of soft iron in front of the compass, and the quadrantal deviation is very small.

In iron ships the semicircular deviation is generally represented by the effect of a magnet at the part of the ship which was south in building, with its blue end turned to the compass.

Armour-plated ships are generally plated after launching; the semicircular magnetism is greatly affected by the position in which they are plated. If they are plated in the direction opposite to that in which they were built, the deviation is generally diminished; when they are plated in the same position in which they are built, the semicircular deviation is generally increased.

Change of Deviation from Time.

What we have called the permanent magnetism is in truth only subpermanent, and changes much, particularly if the ship is exposed to blows or strains, so that the semicircular deviation generally alters very much in the first year after building. The alteration is generally a diminution, although it might be an increase if the compass had by accident or choice been placed in a position where the semicircular deviation from induced magnetism exactly counteracted that from the permanent magnetism.

In consequence of this change the Government has, on the recommendation of the Superintendent of the Compass Department, laid down a rule that no iron ship shall be taken up as a transport till it has made one long voyage.

There is a very remarkable change in the capacity of the soft iron for receiving magnetism by induction, which seems to indicate some molecular change in the iron, *viz.* that it becomes less susceptible of induction by the lapse of time. The effect of this on the strength of the iron is one of the most important points to which attention is now directed.

Change of Deviation from Change of Place.

When a ship sailing south reaches the magnetic equator, the earth's magnetism acts horizontally. The vertical soft iron rod which I have imagined will then have no magnetism, and the semicircular deviation arising therefrom will disappear. When she goes into south magnetic latitudes, the upper end will now become red, and will repel the north end of the needle, and change the direction of the semicircular magnetism caused by the rod.

There will be no corresponding change in the semicircular magnetism caused by the permanent magnetism, except that near the magnetic equator, the directive force of the earth's magnetism being greater than in England, the amount of deviation which the same disturbing force produces will be proportionately diminished.

Careful observations on the changes which take place in the deviation of iron ships in different latitudes are much wanted. They are being made in some of Her Majesty's ships now in the south, but there are no means of procuring such observations from merchant ships.

No change is produced in the quadrantal deviation by a change of the ship's geographical position.

Effects of Special Arrangements of Iron.

The upper or lower ends of all vertical masses of iron produce powerful effects on the needle.

The stern post, iron stanchions, funnels, gun turrets, generally produce large deviations, but if the place of the compass is judiciously selected, they or some of them may be used as correctors.

Horizontal masses of iron, such as deck-beams, produce a great effect, generally increasing the quadrantal deviation and diminishing the directive force. Both causes of error may be reduced by having as little iron as possible immediately below the compass, or within a cone traced out by a line passing through the compass, and making an angle of 54° 45′ with the vertical.

History of the Science.

What has been said will make a short account of the history of the science intelligible. Captain Flinders, in his voyage to Australia in the beginning of the century, was struck by the fact of the north end of the compass being drawn to the ship's head in northern, and to the stern in southern latitudes. He, with great sagacity, compared it to the effect produced by a vertical rod of soft iron, and corrected it by introducing such a rod abaft the compass.

Afterwards, attention was drawn to the same subject in the voyage of Ross and Parry to Baffin's Bay, to which expeditions General, then Captain, Sabine was attached as astronomer. The very large deviations which were found in high latitudes attracted attention, and were carefully observed and discussed.

The observations made in these voyages attracted the attention of Poisson, the great French mathematician, who in his memoirs on magnetism, published in the year 1824, first gave the general formulæ for the effect of iron, which we have already adverted to, and applied them to the observations made in these voyages with much success.

About the year 1840 the British Admiralty, on the report of a committee of scientific officers, comprising General Sabine, Sir J. Ross, and the late Captain Johnson, adopted the system ever since followed in the royal navy, of having a standard compass distinct from the steering compass, placed in a position selected, not with reference to the convenience of the steersman, but for the small and uniform amount of magnetic force at and around it, and of having the deviations of that compass carefully observed by the process of "swinging" the ship, and the deviations of every ship recorded. They also appointed an officer, whose sole or principal duty was the superintendence of the compasses. This office, which has been filled first by Captain Johnson and since his death by Captain Evans, has done more for the advancement of the science than anything else.

No ships in the royal navy have ever been lost from the errors of the compass; and the magnetic history of every ship is so well known, that, in case of the loss of a ship, there would be no difficulty in arriving at a confident opinion as to the effect of the compass error in causing it.

At the same time the attention of Mr. Airy, the astronomer royal, was directed to the particular question of the deviation of the compass in iron ships. Mr. Airy proposed a mode of correcting the semicircular deviation by the application of magnets, and of correcting the quadrantal deviation by the application of soft iron cylinders analogous to the soft iron rods we have supposed, which has been subsequently extensively adopted in the mercantile marine.

In the year 1856 the Liverpool Compass Committee commenced those labours which, principally carried on by their able secretary, Mr. Rundell, have produced three valuable reports, which have contributed greatly to the advancement of this science. These labours are, however, now discontinued.

Practice in the Royal Navy.

In the royal navy, as we have said, each ship has a standard compass in a selected position. A ship is swung or turned round and the deviation observed in a certain number of positions, either by comparison with a compass on shore, or by a comparison with a celestial body, or by observing a distant object. A table of errors is thus observed and recorded—they are reduced by obtaining from them the co-efficients of the semicircular and quadrantal deviation. Observations of horizontal force and of vertical force are also made, from which the amount of heeling error is obtained—and if the amount is large, the heeling error is corrected by the application of a vertical magnet.

The whole process is described, and all the mathematical formula and arithmetical processes, and a number of convenient graphic methods, are given in the 'Admiralty Manual for ascertaining and applying the Deviations of the Compass caused by the Iron of a Ship.' (London: Potter, 1863.)

Practice in the Mercantile Marine.

In the mercantile marine there is no regular superintendence of the adjustment of the compass; it is left to the professional compass adjusters. In many cases there is no separate standard compass, but the steering compass is used for the navigation of the ship, and is often placed so near the stern post and steering gear that it has originally very large and very irregular deviations. These are corrected by powerful magnets. The consequence is, that the slightest change in the magnetism of the ship produces a large error, which is the more dangerous that the captain believes his compass to be free from error.

This great disadvantage, from the indiscriminate use of the method of correction by magnets, is, however, an abuse of the method, and not necessarily attendant on it.

DESIDERATA.

I. *Royal Navy.*

The only desiderata seem to be that greater attention should be paid to the preparing a place for the standard compass, and to the position of the ship in building and plating. The position of the standard compass should be shown in the drawings of every ship, which, before being finally settled, should be submitted for the observations and suggestions of the Superintendent of the Compass Department.

Ships should be built as much as possible head south, and should be plated in the opposite direction to that of building.

Careful recommendation as to the special points to be attended to have been submitted to the Admiralty by the present superintendent of the Compass Department, and we may hope that much benefit will be derived from them.

A proof of what may be effected in this way has already been given in the case of several of the ships of the Imperial Russian Navy, in which the arrangements made under the superintendence of Captain Belavenetz have greatly reduced the amount of deviation.

II. *Mercantile Marine.*

This is a more difficult question, from the want of any general superintendence, or any mode of establishing a uniform system, or any opportunity of receiving, recording, reducing, and discussing the observations made.

Till some change takes place in this respect, it is not probable that much improvement will be introduced, or that merchant ships will make their due contributions to the advancement of science.

What seems desirable is,—

1. That in all iron steam passenger ships there should be a standard compass distinct from the steering compass, placed in a position selected for the small and uniform amount of the deviation at and around it.
2. That the deviations by the standard compass should be ascertained and returned to a department of the Government.
3. That these deviations should be carefully recorded, reduced, and discussed by a competent superintendent.

Many indirect advantages might be expected to flow from following, in these respects, the example of the Royal Navy.

Foreign Countries.

The 'Admiralty Manual' has been translated with more or less modification, and in some respects improvement, by M. Darondeau into French, Captain Belavenetz into Russian, and Dr. Shaub (of the

Austrian Hydrographic Department) into German. In Russia, in particular, the great zeal of Captain Belavenetz, and above all, the appointment of a person of his energy and ability, charged exclusively with the superintendence of this branch of nautical science, has produced, and promises to produce, most important results. In the French and other navies it is not understood that there is any officer charged exclusively with the duty, and we cannot therefore at present look for any contributions from them to the science of the deviation of the compass.

[A. S.]

WEEKLY EVENING MEETING,

Friday, February 16, 1866.

His Royal Highness Prince Arthur, in the Chair.

Colonel Sir Henry James, R.E. F.R.S. &c.

On the Ordnance Survey of Jerusalem.

The speaker commenced by stating that the survey of Jerusalem had been made under his direction, with the permission of the Secretary of State for War, in compliance with the request of the Dean of Westminster, who, on the part of a number of gentlemen interested in endeavouring to improve the sanitary state of the city, undertook to pay the cost of the survey. He also stated, that the Councils of the Royal Society and of the Royal Geographical Society had placed the necessary funds at his disposal to cover the cost of levelling from the Mediterranean to the Dead Sea; and that the Syrian Improvement Society had also contributed the funds required to cover the cost of levelling from Jerusalem to the Pools of Solomon, and for investigating the nature and extent of the present and former supplies of water to the city.

For the execution of these duties Sir Henry selected Captain Wilson, R.E., and a party of Royal Engineers from the Ordnance Survey, including a good surveyor and photographer, Serjeant McDonald, R.E., to take views of the most interesting places in and about the city.

For the illustration of the lecture a plan of the city, on the scale of 25 inches to a mile, with plans of the Haram and Church of the Holy Sepulchre, &c., on the scale of 120 inches to a mile, were exhibited on the wall of the lecture-room, and also plans and sections of the line levelled from the Mediterranean to the Dead Sea, and from Jerusalem to the Pools of Solomon; and several of the photographs were projected by electric light upon a screen, by Dr. Tyndall.

Sir Henry first described the route taken in levelling from Jaffa, by Jerusalem, to the Dead Sea near Jericho; and stated the highest point passed over was at Mount Scopus, which was 2,724 feet above the level of the sea; whilst the height of the Mount of Olives was 2665 feet, of Mount Zion 2550 feet, and Mount Moriah 2440 feet. The level of the Mediterranean was crossed on the road from Jerusalem by Bethany, at 3¼ miles beyond Khan Haddur. At about one mile from Jericho, the line was carried across the plain to a point on the shore of the Dead Sea opposite the small island there.

The depression of the Dead Sea below the Mediterranean was found to be 1292 feet on the 12th March, 1865; but at certain seasons of the year the water fell 6 feet lower, making the greatest depression 1298 feet. The depression, as ascertained by Lieutenant Symonds, R.E., in 1841 was 1312·2 feet. Sir Henry then pointed out the importance of being able to connect the levels of the Jerusalem survey with that of the Mediterranean, and of having a line of "Bench Marks" ($\overline{\uparrow}$), cut on permanent objects, along the whole line levelled, for any future surveys in Palestine, such as those contemplated by the Society which has since been formed "for the "accurate investigation of the Topography, Geology, and Physical "Geography, &c., of the Holy Land for Biblical illustration."

The geological structure of the country was described as consisting of a single great anticlinal fold of strata, of the age of the chalk and lower tertiaries of this country. Specimens of the rocks, with the characteristic fossils, Ammonites, Hippurites, and Baculites of the chalk, with the Nummulites and other tertiary fossils, were exhibited on the table, and also specimens of the highly bituminous limestone found in the cretaceous strata on the eastern slope towards the Dead Sea; the decomposition of which, and the constant flowing up of the bitumen on the surface of that sea, was the probable cause of its having been formerly called the Lake Asphaltitis.

It was then pointed out that the physical or geographical axis of the country between the two seas, which was at Jerusalem itself, from whence the rivers flowed east and west, did not correspond with the geological anticlinal axis, which was at Ain-Jifna and eight miles west of the city; and that all the strata at Jerusalem dipped to the south-east at an angle of about 12°.

The geological plan and section of the ground upon which the city is built was then described. The nummulitic or foraminiferous limestone, locally known under the name of "Cakooli," caps the hills to the east and south of the city, and forms the summits of Mount Scopus, the Mount of Olives, and of the Mount of Evil Counsel, and is 290 feet thick, composed of a soft white limestone with bands of flints.

This formation is succeeded by the cretaceous strata, the uppermost of which is a hard siliceous chalk, called "Missæ," about 70 feet thick; it is upon this that the city itself is built. This is succeeded by a white soft limestone, or indurated chalk, called "Malaki," about 40 feet thick. Under this the red indurated chalk, called "Santa

Croce" marble, is found, but of an unknown thickness. It is from this last formation, which has been largely exposed by denudation at the Convent of the Cross, and in the bottom of the valley of the Kedron at Jacob's fountain, that the marble casing to the Holy Sepulchre and the shafts of the beautiful columns in the Mosque el Aksa, and most of the ornamental stones used in the buildings of the city were taken. The older portions of the wall of the Haram es Sherif have been taken from the "Missæ" and "Malaki" beds, whilst the later additions have been taken from the "Cakooli."

The Topography of the city was then described.

The city is bounded on the west and south by the valley of Hinnom, and on the east by the deep valley of the Kedron, or the valley of Jehoshaphat; these valleys unite at the Fountain of Joab, about half-a-mile to the south of the city, from whence, under the name of the Kedron, the water-course in it descends to the Dead Sea.

The western portion of the promontory thus formed is cut off from the eastern by a valley, which runs southward through the city to join the valley of the Kedron at the Pool of Siloam.

This is the Tyropean valley, or valley of the Cheesemongers, a branch of which runs westward to the citadel.

Another small valley to the north of the Haram es Sherif, entered the valley of the Kedron from the north-west, at St. Stephen's gate.

The ground is thus formed into two spurs, which run out from the higher ground to the north-west of the city, the western and highest of which is the Mount Zion of the Bible, and the Upper city of Josephus; whilst the eastern is Mount Moriah, upon which the temple formerly stood, and the Mosque of Omar, or Dome of the Rock, at present stands.

The citadel occupies the narrow neck of ground between the valley of Hinnom and the Tyropean valley, and barred the only level approach to the ancient city; for that part of the city which lies to the north of the citadel, and west of the main street from the Zion to the Damascus gate, is, comparatively speaking, a modern addition.

The citadel, therefore, was the key of a very strong position for a small city.

A.C. 1048.—"David and all Israel went to Jerusalem, which is Jebus. David took the castle of Zion, which is the city of David, and David dwelt in the castle, therefore they called it the city of David." (1st *Chronicles*, xi.)

"David took the stronghold of Zion, the same is the city of David."

"So David dwelt in the fort, and called it the city of David."
(2nd *Samuel*, v.)

"David began the siege of Jerusalem, and he took the lower city (Acra) by force, but the citadel held out still. When David had cast the Jebusites out of the citadel, he also rebuilt Jerusalem, and named it the city of David, and abode there all the time of his reign."
(*Josephus's* '*Antiquities of the Jews*,' Book vii., chap. 3.)

"Beautiful for situation, the joy of the whole earth, is Mount Zion, on the sides of the north, the city of the great king." (*Psalm*, xlviii.)

There can therefore be no doubt but that this hill is Mount Zion; it has been so called in all subsequent histories, and is so called at present.

From the 21st chapter of 1st *Chronicles* we learn that David bought the threshing-floor of Ornan the Jebusite, and "built there an altar unto the Lord."

Then David said (1st *Chronicles*, xxii.), "This is the house of the Lord God, and this is the altar of the burnt-offering for Israel."

"Then Solomon began to build the house of the Lord at Jerusalem in Mount Moriah, in the place that David had prepared in the threshing-floor of Ornan the Jebusite." (2nd *Chronicles*, iii.)

No one has ever questioned that the temple formerly stood within the Haram es Sherif; and therefore there can be no doubt but that the hill on which it stands has been properly named Mount Moriah.

The city is of an irregular lozenze shape, the longest side facing the north-west, being three-quarters-of-a-mile long, and the shorter sides half-a-mile. It occupies a space exactly equal to the area included between Oxford-street and Piccadilly, and between Bond-street and Park-lane. It is surrounded by high walls with flanking towers, in which there are five gates.

It is intersected from north to south by its principal street, which is three-fifths of a mile long, and runs from the Damascus gate to Zion gate. It is about the length of the street running from St. James's palace along Pall Mall to St. Martin's church.

From this principal street the others, with the exception of that from the Damascus gate down the Tyropean valley, generally run east and west at right angles to it; amongst these is the Via Dolorosa along the north of the Haram, in which is the Roman archway called Ecce Homo.

The city is divided into quarters, which are occupied by the different religious sects.

The boundaries of these quarters are defined by the intersection of the principal street, and that which crosses it at right angles from the Jaffa gate to the gate of the Haram, called Bab as Silsilê, or gate of the Chain.

The Christians occupy the western half of the city, the northern portion of which is called the Christian quarter, and contains the Church of the Holy Sepulchre; the southern portion is the Armenian Quarter, having the citadel at its north-west angle.

The Mahometan quarter occupies the north-east portion of the city, and includes the Haram es Sherif. The Jewish quarter is on the south, between the Armenian quarter and the Haram.

Sir Henry then described the present and the ancient means of supplying the city with water. Of the drainage of the city, he said, there is none in our acceptation of the word, as there is not a single drain leading from the city; and the present water-supply is derived principally from the cisterns in which the rain water is collected, and from Joab's fountain, from whence it is brought in skins on the backs of donkeys, and sold in the city. The water from the Pool of Siloam, although described by Josephus as sweet and in great plenty, is now extremely impure and in small quantity. The ancient conduits for the supply of water were remarkable as engineering works, and rivalled those which have been most recently executed in this country by our most skilful engineers, such as those executed for supplying the city of Glasgow. Two conduits were described and distinguished as the *high-level* and the *low-level conduits*. The low-level conduit was brought from a great distance by the Wady Urtas to below the lowest of the three Pools of Solomon, and from thence passing through two tunnels was led round the lower Pool of Gihon, and round the south end of Mount Zion into the city at the west side of Tyropean valley, at an altitude of 2420 feet. The high-level conduit was brought from a valley to the south of the Pools of Solomon, and led, after passing through a tunnel, above the uppermost of the pools; and from thence by Rachel's Tomb, crossing a valley by means of a syphon made of stone, in lengths of about 5 feet, and having collar and socket joints to connect them, it was led round the upper Pool of Gihon into the Citadel at an altitude of 2528 feet, or 108 feet above the level at which the lower conduit entered the city, and at a sufficient height to supply every house in the city with water. By this arrangement the lower conduit could be supplied with water either through the Pools of Solomon or through pipes in the city. The low-level conduit was supposed to be that which is referred to by Josephus in his 'Antiquities of the Jews,' Book xviii., chap. 3, where he says: "Pilate, the procurator of Judea, undertook to bring a current of water to Jerusalem, and did it with the sacred money, and derived the origin of the stream from the distance of 200 furlongs."

In the Tyropean valley there are three beautiful fountains, which are referred to by Moryson, who visited Jerusalem in 1596, who says, when describing this part of the city, "Here I did see pleasant fountains of waters;" but there is no water to supply them now.

His Royal Highness Prince Arthur examined a stone syphon, similar to that described near Patara, in Lycia, of which a sketch by Major Elphinstone, R.E., was exhibited, as well as models of portions of the two syphons.

The *Holy Sepulchre* was described as a small chamber or crypt, about 6 feet square and 9 feet high, having on the east side so very low an entrance as to oblige people to stoop down in going in or out. It lies exactly east and west, and has a bench on the north side, and to the right of the entrance, on which the body of our Saviour was laid.

This was originally a tomb cut out of the solid rock in the side of the hill, but the Emperor Constantine, A.D. 333, had the rock around it cut away, so as to leave the tomb standing out by itself. He then encased the tomb with marble, and richly ornamented it, and surrounded it with a large open court, paved with marble, and built the Church of the Holy Sepulchre to the east of it. An examination of the ground fully sustains the descriptions which have been given by the contemporary writers, Eusebius and Jerome, and by the Pilgrim of Bordeaux, both as to the Sepulchre itself and its site.

The Sepulchre is surrounded by a handsome circular building, with a dome open at the top; but it much needs the repairs which the Empress of the French is exerting herself to obtain the funds to effect. The Greek church, the principal of the many grouped round the sepulchre, is immediately to the east of the sepulchre, and in the position of the one built by Constantine.

Calvary is 140 feet S.E. of the sepulchre.

The *Haram es Sherif*, or Noble Sanctuary, was described as a quadrilateral enclosure of 35 acres, and nearly one mile in circuit, the northern side being 1042 feet long, the eastern 1530, the southern 922, and the western 1601.

The magnificent Dome of the Rock or Mosque of Omar, as it is commonly called, stands on a platform a little to the west of the centre of the area, and was built A.D. 688 to 691, and restored in the 16th century by Soliman the Magnificent; it is erected over and around the Sakhrah. The Sakhrah is a portion of the natural rock—in fact, the summit of Mount Moriah, the highest portion of which is 4 feet 9½ inches above the marble floor of the mosque, and it is 2440 feet above the level of the sea.

Beneath the Sakhrah there is a cave which is entered by descending some steps on the south-east side. The cave itself is about 9 feet high in the highest part, and 22 feet 6 inches square; a hole has been cut through from the upper surface of the rock into the chamber beneath, and there is a corresponding hole immediately under it, which leads to a drain down to the valley of the Kedron. This hole is supposed to have been made for the purpose of carrying off the blood of the animals sacrificed on the rock, when it was the altar of burnt-offerings to the Temple.

The Mosque, a splendid specimen of Saracenic architecture, consists of a very elegantly-shaped dome, supported on four piers standing in the circumference of a circle 75 feet in diameter; between each of the piers are three pillars, from the capitals of which spring slightly elliptical arches, which assist in carrying the tambour of the dome. This circle is surrounded by an octagonal screen, containing eight piers and sixteen pillars, which carry an entablature, above which are discharging arches, slightly elliptical in shape.

There is a peculiar feature in the entablature of the screen, that over the intercolumnar spaces the architrave is entirely omitted, and over the pillars is represented by a square block cased with marble.

The pillars are of the Corinthian order, averaging 5 feet 11 inches in circumference for the screen, and 7 feet 10 inches for the inner circle; are of various coloured beautiful marbles, and serpentine.

Outside the screen is the main building, also octagonal, composed of the best "Malaki" stone, finely chiselled with close heads and joints, and having on each side seven recessed spaces or bays with plain semicircular heads.

The exterior of the Mosque is richly decorated with marble and "fayence." The casing of various coloured marbles reaches from the ground to nearly the foot of the windows.

The whole internal surface of the dome and tambour is covered with arabesques in mosaic, which, though in some places peeling off, in others retain much of the original freshness of colouring.

The windows are remarkable for the beauty of the tracery, no less than for the brilliancy of the colouring, and the admirable way in which the different colours are blended, producing perfect harmony in the whole.

The Mosque El Aksa, on the south side of the Haram, is a Mahometan place of worship, which has been built upon vaults to bring up a level surface for it.

The Crusaders took Jerusalem in A.D. 1099, and called the Dome of the Rock the "Temple of the Lord," and the Mosque El Aksa, the "Palace of Solomon;" and it was here that King Baldwin founded the celebrated order of Knights Templars.

In discussing the question as to whether the present area of the Haram es Sherif corresponded with the area of the Temple as it was built by Herod, Sir Henry said that a careful examination of this question had led him to the conclusion that there could be no doubt but that it was identically the same.

The northern front is described by Josephus as having the tower of Antonia built on a precipice at the north-west angle; this precipice, in part cut away, still existed, and on the same spot a guard was always now stationed, as it was at the time when the city was occupied by the Romans; this side terminates at the valley of the Kedron, and "was built over it, on which account the depth was frightful," as Josephus also says; and we have in the Pool of Bethesda the immense fosse, and in the small valley previously referred to, the ravine which Titus found such difficulty in procuring materials to fill up, in front of this side. The south side is described by the same author as reaching "in length from the east valley unto that on the west, for it was impossible it should reach any farther;" and this description, with the manner in which the south-east angle is supported on arches, is exactly confirmed by what we now see. Then turning to the architecture of the enclosing walls, we find that, as Josephus says, "both the largeness of the square edifice and its altitudes were immense, and that the vastness of the stones in the front was plainly visible," and this description exactly applies to the lowest, and therefore the most ancient parts of the walls which still remain, as seen at the north-east angle, the south-east, and south-west angles, and at numerous intervening points in which there are immense stones, some of which range from 24 feet to 40 feet in length, and of proportional depth and width.

The architecture of these parts of the walls is moreover distinguished by the broad "marginal drafts" round them, giving a bold and peculiar character to the joints, which have been improperly called "bevelled joints;" and again by the peculiar manner in which the "batter" of the walls was obtained, *viz.* by setting back the courses of stones 4 or 5 inches as they were carried up at the angle.

These facts prove that these remaining portions of the old walls formed part of one design and one work; and when we find a portion of the arch (Robinson's) built in as part of the wall itself, and know that this was one of the arches of the bridge across the Tyropean valley, which was built by Herod to lead to the royal cloisters along the south side of the enclosure—for its position exactly accords with the dimensions given by Josephus—the conclusion is inevitable, that the whole enclosure is identically the same as that of the temple of Herod. The history, the topography, and the architecture are all in accord upon this point.

Sir Henry then described the ancient doorway or postern still existing in the southern portion of the west wall, the lintel of which was 24 feet long in one stone, and the Wailing place of the Jews a little to the north of it, the only part of the wall which is within the Jews' quarter to which they are permitted to have access, and also the great arch having a span of 42 feet and a width of 43 feet, covering the cistern "El Barak," which was discovered by Captain Wilson, and first recognized by him as forming part of one of the four ancient approaches to the temple enclosure on the west side.

The western wall of the enclosure was described as being perfectly straight throughout its length; but from Wilson's arch northwards there is an accumulation of 72 feet of rubbish against it; upon which the modern houses of the Mahometans are built too close together to admit of excavations being made, and which on account of the tombs of the Turkish Effendis, would not be permitted, even if there was room. This portion of the wall is therefore entirely hid, but there is no reason to doubt but that it would be of the same character as the rest, if it could be examined.

The piers of the arches supporting the Haram in the south-east angle are found to range precisely as they should do to support the triple cloister on the south side, and a double cloister on the east side; and if they are not those originally built for that purpose, the present piers must occupy the exact same positions as the original ones did.

After the capture of the city by Titus, A.D. 70, Josephus tells us that he ordered the city to be entirely demolished and its walls to be overthrown, but that the citadel should be preserved as a monument of his good fortune. The citadel had been rebuilt by Herod, and from the description given by Josephus of the towers built by him—*viz.* that they were built up to a certain height perfectly solid—and from the character of the architecture, which corresponds with that found all round the Haram, there seems no doubt that the tower, called the Tower of David, is one of those built by Herod.

Sir Henry concluded by observing that "notwithstanding the very "opposite views with respect to the sites of the holy places which have "been brought forward in this lecture-room, I feel firmly convinced "that the traditional sites are the true sites of the Holy Sepulchre, the "Temple, Mount Zion, and Mount Moriah."

[H. J.]

WEEKLY EVENING MEETING,

Friday, February 23, 1866.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

WILLIAM PENGELLY, ESQ. F.R.S. F.G.S.

On Kent's Cavern, Torquay.

AMONGST the numerous beautiful valleys in the neighbourhood of Torquay, there is one, about a mile eastward from the harbour, running north and south, and terminating in the latter direction on the northern shore of Torbay. About half-a-mile from this termination, a transverse valley enters it on the western side, and in the angle formed by the junction of the two there stands a small, wooded, limestone hill, which contains the celebrated Kent's Cavern, or Kent's Hole.

The rocks composing the entire Torquay peninsula are limestone with interstratified calcareous shale, greenstone, clay-slate, and a compact reddish grit; all of which, with the possible exception of the greenstone, belong to the Devonian system. The slate and grit, which are traversed by quartz veins, underlie the limestone, but form the highest hills of the district. The overlying soil is frequently an ochreous red loam mixed with angular stones, from a few inches to fully twelve feet thick. It is sometimes sufficiently tenacious and free from stones to be used for making bricks. Numerous narrow fissures traverse the limestones; and many of them are filled with a similar admixture of clay and stones, or sand, or gravel consisting of well-rounded materials, and in some cases derived from somewhat distant parts of the county. Near Hope's Nose, the northern horn of Torbay, and scarcely a mile from the cavern, there is a fine example of a raised beach, about 30 feet above the sea, and containing a large number of well-rolled flints, as well as the shells of various species of mollusks, all of which still inhabit the adjacent bay. A considerable accumulation of gravel, largely composed of rolled flints and Dartmoor rocks, occurs on Milbern Down, about five miles north-westerly from the cavern.

Omitting one or two mere slits, which have long been blocked up from within, the cavern has two entrances in one and the same low natural cliff, which runs north and south on the eastern scarp of the hill. They are about 50 feet apart, 190 feet above the level of mean tide, and from 60 to 70 feet above the bottom of the valley immediately below. The northern entrance is a rude triangle, about 6 feet high and 8 feet wide at the base. Several lithodomous perforations occur in the limestone near its vertex. The southern opening is somewhat larger, and is a natural arch, having a continuous limestone base or chord.

Though the cavern has been known from time immemorial, it did not attract the attention of scientific men until 1824, when Mr. Northmore and Mr. W. C. Trevilyan found a few bones in its deposits. In 1825 the Rev. Mr. McEnery commenced the investigations which were continued until 1829, and rendered the scene of his labours famous. After his decease his papers passed into the possession of Mr. Vivian, by whom they were published in 1859. In 1840 Mr. Godwin-Austen read to the Geological Society of London a paper descriptive of researches which he had made in the cavern. In 1847 Mr. Vivian read to the same society, and also to the British Association, a paper embodying the results of an investigation of the cavern, made the previous year, by a committee of the Torquay Natural History Society.

These investigations appear to have been made carefully, and the explorers are unanimous in stating that flint implements were found commingled with the remains of extinct animals, in undisturbed cave earth, beneath the stalagmitic floor. Mr. Godwin-Austen adds that the *bones* of man occurred under precisely the same conditions.

According to Professor Owen's 'British Fossil Mammalia and Birds,' remains of the following animals, of which those in italics are extinct species, have been found in the cavern:—Great Horse-Shoe Bat, Shrew, *Ursus priscus*, *Ursus spelæus*, Badger, Polecat, Stoat, Wolf, Fox, *Hyæna spelæa*, *Felis spelæa*, Wild Cat, *Machairodus latidens*, Water Vole, Field Vole, Bank Vole, Norway Hare, Rabbit, *Lagomys spelæus*, *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus fossilis*, *Hippopotamus major*, *Megaceros hibernicus*, *Strongyloceros spelæus*, Red deer, and Man. The last is on the authority of Mr. Godwin-Austen.

It is well known that even scientific men either discredited or explained away these alleged discoveries of the inosculation of human industrial remains with the bones of the extinct mammals, until 1858, when the results of the systematic exploration of the Brixham Cavern induced many geologists to suspect that the discoveries which again and again had been reported from Kent's Cavern might after all be worthy of credence; and in 1864 the British Association appointed a committee, consisting of Sir C. Lyell, Sir J. Lubbock, Professor Phillips, Mr. Vivian, Mr. J. Evans, and Mr. Pengelly, to make a systematic exploration of the cavern, which the proprietor, Sir L. Palk, Bart., immediately placed in their exclusive custody.

Mr. McEnery and his successors, as well as the numerous visitors, invariably used the northern entrance. The southern, which had long been blocked up, opens at once into a spacious chamber, which the Committee selected for their investigations, partly because of its accessibility, but mainly on account of its deposits being certainly intact. A mode of exploration was decided on, intelligent and trustworthy workmen were engaged, and the work, consigned to the superintendence of the two resident members of the committee, commenced on March 28, 1865. The encouraging report presented in September last induced the British Association not only to repeat, but to double their liberal grant of the previous year.

The following, in descending order, is the succession of deposits found in the chamber:—

1. Huge blocks of limestone which had fallen from the roof. Many of them required blasting in order to their removal. The largest measured 19½ feet long, 9 feet broad, 2½ thick, and must have weighed fully 33 tons. In some instances two or three blocks lay one on another. Sheets of stalagmite sometimes lay between and cemented them together, or invested the whole so as to form a dome-shaped mass, whilst others were without any trace of this material.

2. Beneath and between these blocks lay a stratum of black muddy mould from 3 to upwards of 12 inches in depth.

3. Next below was a floor of stalagmite from about 1 to 3 feet in thickness. It was firmly cemented to the walls, and, with a few exceptions, extended across the chamber. In some cases it was crystalline, compact, and hard; in others granular or earthy. Most commonly it consisted of alternate crystalline and non-crystalline laminæ. It contained numerous fragments of limestone, some of them attaining the size of large blocks; and in the lower portion it graduated into an intractable concrete.

4. Still lower was the ordinary ochreous red cave-earth, with about 50 per cent. of angular fragments of limestone, varying from thin bits measuring less than a square inch, to blocks as large as some of those found on the surface. In some cases the stones and earth were mixed in about equal quantities, in others the earth or stones greatly preponderated. Thin films of stalagmite of limited area occurred at all depths, sometimes encrusting a bone or stone, in others cementing the materials into small lumps of breccia.

The entire accumulation was destitute of any approach to stratification, and the stones lay at all angles, without any tendency to symmetrical arrangement. At present the cave-earth has not been excavated beyond four feet below the stalagmite, so that nothing is known respecting its depth or what may lie beneath it. The black muddy soil lies immediately on it in the few spots where there is no stalagmite, but the line of junction is in all cases sharp and well defined.

There can be no doubt that the early explorers abstained from carrying on researches in this chamber on account of the huge limestone blocks overlying the deposits. They are at once the cause, and a proof that the accumulation remained intact.

It is believed that the method of exploration which from the commencement has been rigidly followed, is at once simple and trustworthy, and that it renders it easy to determine the precise situation of every object which has been found. It is as follows:—

1. The black mould between the limestone blocks was carefully examined and removed.

2. The blocks themselves were blasted, and otherwise broken up, and taken out of the cavern.

3. A "datum line" was stretched horizontally from a fixed point at the entrance to another at the back of the chamber.

4. At distances of one foot, lines were drawn transversely across the chamber at right angles to the datum, so as to divide the entire area into belts or "parallels" one foot wide.

5. In each parallel, the black mould which had underlain the blocks of limestone, and then the stalagmite floor, were examined and removed, so as to expose the surface of the cave-earth.

6. The red cave-earth in each parallel was excavated in four successive "levels," each a foot deep, and extending across the chamber. Each level was divided into three-feet lengths or "yards," measured on each side from the datum, so as to form a right and left series. For convenience of working, as well as to guard against the risk of slips, the sections have been limited to the depth of four feet.

The material contained in each "yard," or horizontal prism, has been first carefully examined *in situ* by candle-light, next taken to the entrance and re-examined, and then removed outside the cavern and once more looked over. A box has been appropriated exclusively to the objects found in each yard, and every evening the boxes, each containing a label with the data necessary for defining the exact position of its contents, and securely packed, have been sent, under lock, to the honorary secretary, who at once cleaned and repacked the specimens, numbered the labels, and recorded in his diary the results of the day's investigation.

The same method has been followed in the examination of the black mould and the stalagmite, with the single exception that they have not been divided into "levels" and "yards."

If from any cause the position of an object was doubtful, such object has been placed in a box marked "uncertain," and thus all untrustworthy evidence has been eliminated. With rare exceptions, the cavern has been visited daily by the superintendents, and monthly reports have been forwarded to the chairman of the committee.

The objects found in the black mould, above the stalagmite, form a very miscellaneous collection, which includes articles of various eras, from the present day back to pre-Roman times, and thus represents at least two thousand years. It consists of various kinds of stones, human industrial remains, bones of different animals of existing species, land and marine shells, and perforated shells of hazel-nuts. The stones, in most cases well rounded, and occasionally lithodomized, are fragments of limestone, quartz, red grit, slate, greenstone, and flint,—

all, excepting the last, derivable from the rocks of the district. There can be no doubt that they were taken to the cavern by man.

The human industrial remains are pottery, and articles in stone, bone, and bronze.

The pottery occurs in fragments; nothing approaching a perfect vessel has been found. The sherds represent a large number of utensils ranging from pre-Roman, through Roman and mediæval, to modern times. Many of them are black, coarse in texture, and more or less ornamented.

Amongst the articles in stone, there are whetstones; fragments of slate, some of which are obviously portions of curvilineal plates, used, perhaps, as covers for the earthenware vessels; "spindle whorls," formed of Devonian grit, Triassic sandstone, slate, chloritic schist, and Kimmeridge clay, and differing in dimensions and finish, some being very rude, whilst others are even elaborately ornamented; a quadrantal fragment of an ellipsoidal quartzite pebble, resembling those which compose the Triassic "pebble-bed" near Budleigh Salterton, and which appears to have been used for polishing; and a few flint flakes, some of a dark, others of an almost white colour.

The bone implements comprise a comb, resembling in size and outline a small shoe-lifter, with strong teeth cut in its broad end; a spoon, neatly formed out of a rib; a chisel; and a wedge.

The bronze series includes a fibula; portion of a spoon; a spear head; a socketed celt; and two or three rings. In this connection may be mentioned a large portion of a cake of smelted copper.

Of the shells, the terrestrial forms are chiefly various species of snail. They occur in all stages of growth, and are probably the relics of a colony which had taken possession of the cavern. The marine species are the limpet, whelk, oyster, solen, pecten, mussel, cockle, and the internal shell of a small cuttle-fish. Their presence is due, no doubt, to human agency.

The stalagmitic floor, though broken into small fragments and carefully examined, has not yielded a large collection of objects. In it have been found pieces of charcoal; marine and land shells; and a few remains of animals, most of them existing species, but including teeth of a bear, probably *Ursus spelæus*.

The red cave-earth, below the stalagmite, contained pebbles of various kinds, some of them certainly derived from Dartmoor and other somewhat distant localities, and varying from the size of peas to that of a hen's egg; an immense quantity of bones and teeth of recent and extinct mammals; flint implements; whetstones; and a stone hammer.

The bones are of greater specific gravity than those found in the overlying black mud. Most of them are of a chalky whiteness when cleaned; but a few are discoloured, and present such marks as are sometimes left by mosses and lichens on objects on which they have grown. A considerable number of the long bones have been split longitudinally, as if for the extraction of the marrow; and all that are thus split, as well as many others, including fragments of antlers and even teeth, present distinct indications of having been gnawed. Most of those found immediately beneath large blocks of limestone are crushed. A few have obviously been rolled, and several pieces of burnt bone have been met with. A large portion of the osseous débris occurs in the form of mere splinters. Lumps composed of finely comminuted bone, bony fæcal matter, and red loam are here and there abundant.

Nothing like an entire, or even a considerable portion, of a skeleton has been found. The principal identifiable remains are teeth, amongst which are those of the cave-bear, cave-lion, cave-hyæna, fox, probably more than one species of horse, ox, several species of deer, the tichorhine, rhinoceros, and the mammoth. The hyæna, and, after it, the horse and rhinoceros, are the most prevalent forms. The relics of the mammoth —tusks and teeth—are those of very young animals. The early explorers, however, 'frequently found, in other parts of the cave, the remains of adults of this species.

Without including doubtful specimens and mere chips, about seventy "flint" implements have been found. Like the bones, they are least numerous in the uppermost foot or "level" of the cave-earth. Some are of a light grey, others of a cream colour, or almost white; the latter, however, is apparently due to a natural or artificial metamorphosis, producing a more or less earthy texture, which rarely extends quite to the centre. The flint varies much in purity, and is sometimes more or less cherty. Some of the specimens are fragments only, others were found broken but with the parts lying in contact, whilst many are perfect. A few seem scarcely or never to have been used, and none of them present any traces of having been rolled. Some are highly wrought, but never polished; others seem to have been fashioned with but little effort or skill; whilst occasionally a rather large sharp splinter is met with, such as was probably struck off in fashioning a more elaborate tool. The most perfect implements are of two kinds:—flakes, flat or concave on one face, and carinated on the other; and oval implements, worked to an edge all round. Of the latter there are three specimens, all carefully made and well finished; one of them was found in the third, and two in the fourth, or lowest level yet excavated.

The whetstones, of which there are two, are formed of hard, fine-grained, dark-green grit. One was found in the first or uppermost "level" of the red loam, in a small cavity in the wall of the chamber, having over it a thick stratum of limestone *in situ*, and over this again was a mass of stalagmitic breccia, eight feet thick. The second was met with in the second "level," near the middle of the chamber, where the overlying stalagmite was twenty-six inches thick and extended in unbroken continuity and in all directions for several yards.

The stone hammer is simply an ellipsoidal pebble of hard Triassic sandstone, which from the character of its protuberant surface, appears to have been held by the fingers applied at the extremities of its shortest axis, and used for breaking.

The results of the exploration now in progress have confirmed most, and contradicted none, of those recorded by the earlier investigators. Compared with the previous evidence, that recently found is in a few cases defective, but never conflicting. The committee, like Mr. McEnery, Mr. Godwin-Austen, and the Torquay Natural History Society, have found unquestionable human industrial remains, in the undisturbed cave-earth below the stalagmite, mixed up with the bones and teeth of the ordinary extinct cave mammals; but, unlike Mr. McEnery, they have not yet found any traces of ***Machairodus*** nor of ***Hippopotamus;*** nor have they, like Mr. Godwin-Austen, met with any part of the human skeleton.

The speaker remarked, that he alone must be held responsible for any inferences which he might draw from the facts which had been enunciated; he also wished it to be understood that, since the evidence cannot be considered complete until the exploration has closed, such inferences must be regarded as provisional only, and not necessarily definitive.

The fall of the blocks of limestone from the roof has been ascribed by some to earthquake shocks; by others, to change of dimensions arising from changes of temperature. It may be objected to the first hypothesis, that it renders it necessary to call in the aid of convulsion very repeatedly, since the blocks fell at intervals throughout the periods represented by the cave-earth, the stalagmite, and the black mud, as well as after the greater part, at least, of the latter was introduced; and to the second, that the cavern temperature is constant. It seems more probable that, so to speak, the blocks were cut out successively by the action of water charged with carbonic acid, and percolating through the roof along the two systems of joints which traverse the limestone.

That the stalagmitic floor was not formed by a stream, supersaturated with carbonate of lime, flowing through the cavern, but by drip from the roof, is evinced by its occasional discontinuity on areas by no means above the common level; as well as by the fact, that it was immediately beneath unusually large stalactites depending from the roof that the floor attained its greatest thickness, and rose in considerable bosses.

Since none of the flint implements have been rolled, and some of them appear new and unused, it may be concluded that man was at least an occasional visitant of the cavern. The occurrence, moreover, of large flint splinters with sharp edges renders it probable that he made it his habitual residence, and manufactured his tools there. The same inference may be drawn from the whetstones, the stone hammer, and the burnt bones; and it receives further confirmation in the numerous long bones split longitudinally, since it is difficult to conceive of this being achieved by less than human agency.

But since these as well as many other bones are scored with teeth-marks, probably by the hyæna in most cases, and a large amount of bony fæcal matter occurred at all levels and in every part of the area, it seems equally certain that the cavern was at least the occasional home of this powerful carnivore, which dragged into his domicile the remains of his brute contemporaries, or made a meal by gnawing the scattered remnants of the human feast. As man, however, could not have shared his home with so undesirable a fellow-lodger, it seems probable that the latter resided there only whilst the former was absent; and when it is remembered that in a climate such as the British a savage population must be necessarily sparse, it will be seen to be not unlikely that hunting expeditions frequently took man considerable distances, and for protracted periods, from his home.

That the cave-earth accumulated gradually and slowly may be inferred from the facts that traces of this alternate tenancy, large blocks of limestone, and films of stalagmite encrusting stones and bones, or cementing them into a firm concrete, occur at all levels and in all parts of the chamber.

Much of the red earth forming the staple of the cavern deposit may be, perhaps, the earthy residuum of the impure limestone of the district, and especially of the interstratified shale, the calcareous matter having been removed by the action of acidulated water; and a portion of this may have been derived from the interior of the cave itself. It is obvious, however, that at least parts of the deposit were introduced from without, since it contains no inconsiderable amount of material which the cavern hill could not supply, such as *pebbles* of Devonian grit—probably from an adjacent and loftier hill—quartz, flint, granite, and other Dartmoor rocks, and crystalline schists from the southern angle of the county.

It cannot be supposed that these pebbles were selected by man, as many of them are much too small to serve any useful purpose.

Since there are no open fissures in the roof of the cavern, the materials from the exterior must have been introduced through the lateral entrances, and in all probability by the action of water,—an hypothesis in harmony with the facts that the surface of the deposit is everywhere below the level of the top of the openings, and that some of the bones are rolled.

It may be concluded, too, from the absence of a stratified arrangement of the materials, that the transporting agent was neither the sea nor an engulfed permanent stream, but in all probability an occasional land-flood, which, when the bottom of the valley was but little below the level of the base of the entrances, from time to time entered the cavern. That the sea did not introduce the deposit may be inferred also from its containing no trace of marine organisms.

The acceptance of the foregoing hypothesis renders it necessary to suppose that since the era of the deposit the adjacent valley has been deepened at least 60 feet, either by the excavation of a corresponding amount of hard semi-crystalline limestone, or by the re-excavation of a pre-existent valley which had been filled up with gravel. The hypothesis of excavation is somewhat appalling from the enormous chronological demand which it necessitates, whilst that of re-excavation, though perfectly compatible with the most extended antiquity, renders it possible to compress the change of surface-configuration within such moderate time-limits as other related phenomena may require.

It is well known that the valleys of the Bovey and Teign—but a few miles from the cavern—not only existed, but were deeper than at present in early Tertiary times; that at their confluence a lacustrine formation, upwards of 50 fathoms in thickness, was deposited in the Lower Miocene period; that long subsequently a thick accumulation of gravel, consisting mainly of fragments of granite and flint, covered it unconformably, and extended very far beyond it; that denudation has everywhere swept off large portions of this gravel; that on it there lies, on Bovey Heathfield, a white clay containing *Betula nana*, and other plants betokening a very cold, perhaps a glacial climate; that similar gravels fill pockets and fissures in the limestone of the Torbay district, and reach the height of nearly 300 feet; that from the Teign eastward, all the Devonshire valleys are partially occupied with gravel extending from their lowest level to the summits of the hills which bound them, and have certainly been twice excavated—primarily before, secondarily and less completely, after the gravel period,—all the old valleys being re-opened, but not deepened, and no new ones cut, even in comparatively soft Triassic sandstone; that the valley bounding the cavern hill, and on the slopes of which the cavern entrances are situated, was certainly upwards of 200 feet deep prior to the introduction of the cave deposit; and that since that time no appreciable effect has been wrought in the slopes of the cavern hill above the "entrances," since the perforations at their level, drilled by marine lithodomi prior to the era of the cave-earth, instead of being effaced by denudation, are still of considerable depth;—facts, all of them, harmonizing with the hypothesis of secondary, rather than of primary excavation. The former, moreover, accounts for the presence of the pebbles of distant derivation mixed up with the cavern deposit.

It is occasionally argued that, in consequence of their greater specific gravity, the flint implements may have sunk through a pulpy deposit to a lower level than they would have occupied otherwise, and thus were mixed up with the bones of animals of earlier times. This rejoinder is effectually rebutted by the fact that very large masses of limestone, as well as the flints, occur at all levels, having no other support than that afforded by the deposit. Moreover, the crushed bones lying immediately beneath these masses show that the deposit was compact, unyielding, and capable of offering a firm resistance to even heavy falling bodies.

It has been asserted that the statement of the inosculation of human industrial remains with the bones of extinct animals was accepted by geologists with a haste, and, indeed, an eagerness but little comporting with the gravity of the subject, or with the spirit of philosophy. In reply, it cannot be necessary to do more than to state briefly the history of the Kent's Cavern explorations. But for the strong hand it seems equally certain that the cavern was at least the occasional home of this powerful carnivore, which dragged into his domicile the remains of his brute contemporaries, or made a meal by gnawing the scattered remnants of the human feast. As man, however, could not have shared his home with so undesirable a fellow-lodger, it seems probable that the latter resided there only whilst the former was absent; and when it is remembered that in a climate such as the British a savage population must be necessarily sparse, it will be seen to be not unlikely that hunting expeditions frequently took man considerable distances, and for protracted periods, from his home.

That the cave-earth accumulated gradually and slowly may be inferred from the facts that traces of this alternate tenancy, large blocks of limestone, and films of stalagmite encrusting stones and bones, or cementing them into a firm concrete, occur at all levels and in all parts of the chamber.

Much of the red earth forming the staple of the cavern deposit may be, perhaps, the earthy residuum of the impure limestone of the district, and especially of the interstratified shale, the calcareous matter having been removed by the action of acidulated water; and a portion of this may have been derived from the interior of the cave itself. It is obvious, however, that at least parts of the deposit were introduced from without, since it contains no inconsiderable amount of material which the cavern hill could not supply, such as *pebbles* of Devonian grit—probably from an adjacent and loftier hill—quartz, flint, granite, and other Dartmoor rocks, and crystalline schists from the southern angle of the county.

It cannot be supposed that these pebbles were selected by man, as many of them are much too small to serve any useful purpose.

Since there are no open fissures in the roof of the cavern, the materials from the exterior must have been introduced through the lateral entrances, and in all probability by the action of water,—an hypothesis in harmony with the facts that the surface of the deposit is everywhere below the level of the top of the openings, and that some of the bones are rolled.

It may be concluded, too, from the absence of a stratified arrangement of the materials, that the transporting agent was neither the sea nor an engulfed permanent stream, but in all probability an occasional land-flood, which, when the bottom of the valley was but little below the level of the base of the entrances, from time to time entered the cavern. That the sea did not introduce the deposit may be inferred also from its containing no trace of marine organisms.

The acceptance of the foregoing hypothesis renders it necessary to suppose that since the era of the deposit the adjacent valley has been deepened at least 60 feet, either by the excavation of a corresponding amount of hard semi-crystalline limestone, or by the re-excavation of a pre-existent valley which had been filled up with gravel. The hypothesis of excavation is somewhat appalling from the enormous chronological demand which it necessitates, whilst that of re-excavation, though perfectly compatible with the most extended antiquity, renders it possible to compress the change of surface-configuration within such moderate time-limits as other related phenomena may require.

It is well known that the valleys of the Bovey and Teign—but a few miles from the cavern—not only existed, but were deeper than at present in early Tertiary times: that at their confluence a lacustrine formation, upwards of 50 fathoms in thickness, was deposited in the Lower Miocene period: that long subsequently a thick accumulation of gravel, consisting mainly of fragments of granite and flint, covered it unconformably, and extended very far beyond it: that denudation has everywhere swept off large portions of this gravel: that on it there lies, on Bovey Heathfield, a white clay containing *Betula nana*, and other plants betokening a very cold, perhaps a glacial climate: that similar gravels fill pockets and fissures in the limestone of the Torbay district, and reach the height of nearly 300 feet: that from the Teign eastward, all the Devonshire valleys are partially occupied with gravel extending from their lowest level to the summits of the hills which bound them, and have certainly been twice excavated—primarily before, secondarily and less completely, after the gravel period,—all the old valleys being re-opened, but not deepened, and no new ones cut, even in comparatively soft Triassic sandstone: that the valley bounding the cavern hill, and on the slopes of which the cavern entrances are situated, was certainly upwards of 200 feet deep prior to the introduction of the cave deposit: and that since that time no appreciable effect has been wrought in the slopes of the cavern hill above the "entrances," since the perforations at their level, drilled by marine lithodomi prior to the era of the cave-earth, instead of being effaced by denudation, are still of considerable depth:—facts, all of them, harmonizing with the hypothesis of secondary, rather than of primary excavation. The former, moreover, accounts for the presence of the pebbles of distant derivation mixed up with the cavern deposit.

It is occasionally argued that, in consequence of their greater specific gravity, the flint implements may have sunk through a pulpy deposit to a lower level than they would have occupied otherwise, and thus were mixed up with the bones of animals of earlier times. The rejoinder is effectually rebutted by the fact that very large masses of limestone, as well as the flints, occur at all levels, having no other support than that afforded by the deposit. Moreover, the uncrushed bones lying immediately beneath these masses show that the deposit was compact, unyielding, and capable of offering a firm resistance to even heavy falling bodies.

It has been asserted that the statement of the inosculation of human industrial remains with the bones of extinct animals was accepted by geologists with a haste, and, indeed, an eagerness but little comporting with the gravity of the subject, or with the spirit of philosophy. In reply, it cannot be necessary to do more than to state briefly the history of the Kent's Cavern explorations. But for the strong hand of scientific authority Mr. McEnery would have published at once his discoveries made forty years since. Mr. Godwin-Austen's paper, in 1840, experienced an undeserved neglect; and in 1847, the Geological Society of London, in the three lines they devoted to Mr. Vivian's paper, declined to do more than to state that during the researches of the committee of the Torquay Natural History Society, "the bones of various extinct species of animals were found in several situations." The statement "that relics of human art were found *beneath* the unbroken floor of stalagmite" was entirely ignored; and this in a journal which, on its wrapper, announces "that the authors alone are responsible for the facts and opinions contained in their respective papers."

The recent researches in the cavern show that the interrogative objection, "Where are the bones of the implement-makers?" proves nothing, or proves too much. It is true that the committee have not found human remains amongst the implements and the bones of extinct mammals below the stalagmitic floor; but it is also true that they have not been more successful in the black mould above. Pottery, implements and ornaments in metal, bone, and stone, the remnants of man's fires, and the relics of his feasts are numerous, and betoken the lapse of at least two millenniums; but here, as well as below, the only evidences of his existence are the results of his handiwork. No vestige of his osseous system has been met with.

[W. P.]

WEEKLY EVENING MEETING,

Friday, March 2, 1866.

GEORGE SCHARF, Esq. F.S.A.

SECRETARY AND KEEPER OF THE NATIONAL PORTRAIT GALLERY,

On Portraiture: its Fallacies and Curiosities as connected with English History.

IT will scarcely be necessary to enter into details respecting the origin and earliest applications of portraiture. The pages of Pliny, Herodotus, Ælian, and Plutarch afford numerous examples; and for the more modern periods of art, we have but to turn to Vasari, Van Mander, Houbraken, and Ridolfi, to find abundant historical records in continuation. The taste for collecting portraits of eminent persons appears to have prevailed in very early times. Varro, the contemporary of Cicero, compiled an album or collection of 700 biographies, extending from the period of Homer and Hesiod to his own day. These were accompanied by portraits of the respective persons, which he seems to have possessed some peculiar means of reproducing and multiplying at will.

Even at these early times, we learn from Pliny that, when some desirable portrait was not to be met with, artists were already in the habit of composing ideal features to supply the deficiency.

In comparatively recent times the system adopted by Varro was pursued by Paulus Jovius, Bishop of Nocera, who flourished at the beginning of the sixteenth century. He was born in 1483, the same year with Raphael, Rabelais, and Martin Luther. He also formed a large collection of portraits of the most illustrious men of all periods, which he combined with biographical notices, under the denomination of a Musæum. These were afterwards published with woodcut illustrations, having pithy epigramatic sentences under each, in imitation of the system adopted by Pomponius Atticus, the Roman collector. This volume is well known as the 'Elogia of Paulus Jovius,' and deserves especial notice for the spirit and character with which the woodcut portraits have been executed.

This curious collection first suggested to Vasari the commencement of his invaluable volumes, 'Lives of the Italian Painters,' which were intended originally to illustrate the portraits he had collected, and in which now, clever as they undoubtedly are, the woodcut illustrations hold a very subordinate position. The book was first published in 1550, and a second edition appeared at Florence in 1568. Vasari executed for the Grand-Duke, his patron, an extensive series of actual portraits of the great men who flourished in the time of Cosimo Vecchio, to serve as decorations for the ducal palace at Florence.

The taste of Varro, Jovius, and Vasari, was followed in England by the illustrious John Evelyn, Lord Chancellor Clarendon, and Secretary Pepys, and it is to their exertions that we are indebted for the preservation of many interesting facts relating to portraiture, and for a knowledge of the subjects of some of the finest paintings of that class.

The letters written by John Evelyn, in 1667, to his friend Lord Clarendon, and published in his correspondence, are well worthy of consideration by all who are interested in comparing the portraits of eminent men. Even as late as August, 1689, we find him earnestly pursuing this theme, and communicating valuable advice on the subject to his friend Pepys, whose extensive collections were eventually deposited at Magdalen College, Cambridge.

Unless implicit reliance can be placed on the authenticity of the likeness, a portrait becomes worthless. The soundness of claims to genuineness may be tested and authenticated in various ways; but especially by reference to pictures preserved in family mansions, historical descriptions, and by a comparison with contemporary engravings of the best class, bearing inscriptions which afford both names and dates of the persons represented and of the artist also who painted the likeness. The value of inscriptions upon paintings, medals, and seals, has been instanced in numerous cases by John Evelyn, Visconti, and various writers upon the history of art. The lineaments of a face do not always correspond with the idea that may be formed from the known actions of an individual, and, consequently, in the absence of some inscription to convey the necessary information, many interesting countenances would be in danger of being passed by unnoticed.

A remarkable instance of this may be cited in a well-known tetradrachma, probably struck at Alexandria 33 B.C., bearing on one side a profile of Cleopatra and Marc Antony on the other. Neither of these faces in the least degree accords with the notion that we have formed of their personal appearance, and yet the legend in Greek characters around them precludes the possibility even of uncertainty. Again, the same profiles are repeated on Roman coins, with the inscriptions in the Latin language.—(Visconti, Icon. Grecque, tom. 3, tav. xv. nos. 5, 6.) It is only too frequently that the artist employs written characters to record his own name exclusively; omitting at the same time to convey that of the person represented. Of this omission, both in painting and sculpture, ancient and modern, John Evelyn, in his 'Sculptura,' very justly complains.

Inscriptions and coats of arms also frequently occur upon painted portraits; these, it need hardly be stated, when genuine, are of the greatest possible service.

But it is not always that they can be relied upon. As the artist himself must necessarily have delayed introducing them till the picture was completely finished, they rarely appear as if thoroughly incorporated or harmonized with the rest of the colours. This circumstance has been particularly favourable to the addition by subsequent fabricators of dates, combined with armorial bearings, and promoted the forgery of some recognisable signatures upon them.

There are, however, safe and sure tests by which these frauds may be detected. Genuine old colour, that has remained on a panel or canvas for centuries, acquires a surprising degree of hardness, sufficient at least to resist the application of solvents that would disturb and carry away upon the slightest touch a considerable body of modern or comparatively new paint. I have myself seen masses of colour swept off from a picture by similar applications, revealing immediately the genuine old painting beneath, and in all its original purity.

The ingenious manner in which names and dates have been tampered with, would form an amusing although not very creditable chapter in the history of art. Engravings also are liable to a similar amount of alteration. Occasionally, when the demand for a portrait has unexpectedly ceased, the engraver has found it expedient to alter the head to that of some more popular person, leaving the rest of the plate untouched, and, by at the same time changing the title below, to derive advantage from the sudden production of an apparent novelty. Many plates thus altered are well known. A harmless instance may here be cited in Elstracke's early portrait of Whittington, Lord Mayor of London, where, in accordance with the taste of the day, the artist had represented him as resting his hand on a skull. This failing to take with the public, induced the engraver to change the skull into a *cat*, after which, judging by the very worn state of some of the impressions, the print met with a very large circulation.*

The following plates were altered both in faces and figures as far as appeared necessary to suit the writing:—

Queen Elizabeth on her throne in Parliament, to James I.

King Charles on horseback, after Van Dyck, to Cromwell.

Cromwell standing between two pillars, by Faithorne, into King William III.

King Christian IV. of Denmark, into Oliver Cromwell.

The following changes are instances of the fraudulent practices and are intended to put the unwary on their guard. In these cases the inscriptions alone have been altered; the face in each instance remaining perfectly the same:—

David Nuyts, by Suyderhoff, became afterwards Sir Hugh Myddleton.

Archbishop Leighton, of the time of Charles I., became Rev. John Horne, parson of Brentford (Horne Tooke).

Coleridge, the poet, became Lord Cochrane.

Mr. Incledon, the singer, as Captain Macheath, became Greenacre, the murderer, in Newgate.

Mrs. Humphrey, wife of an engraver, became successively Mrs. Fitzherbert and Caroline Princess of Wales.

Mr. Pond, son of a horsedealer, became Peter Pindar.

Another important means towards detecting error in the names and offices of persons represented in portraiture, may be derived from the study of costume. This, if associated with a general knowledge of the various styles of art at different periods, will generally lead to a satisfactory conclusion. In nearly all cases, painters unconsciously represented historical characters and events, however remote the times may have been, in dresses and ornaments peculiar to their own day. Even when some deviation was attempted, as in the portraits of our earliest kings, some minor details, such as the form of cap, feather, construction of armour, buckles, or details of ornament, will be found to betray the real time when the painting was made.

It is in this manner that portraits called Rosamond Clifford, ornamented with lace cap and ruff, and Queen Elizabeth and Queen Mary as little girls in the costume of young ladies of the seventeenth century, lose all claim on our acceptance.

Foreign portraits occasionally have been mistaken for English ones. Thus, the 'Three Children of Christian II., King of Denmark,' at Hampton Court Palace, were named by Vertue, and engraved by him as, the 'Three Children of King Henry VII. of England.' Unfortunately, the figure of the eldest boy in this group has been copied for the Houses of Parliament, and appears there in the Prince's Chamber, Westminster, under the denomination of 'Arthur, Prince of Wales.'

---

* For this, and many of the following instances, I am indebted to the experience of my friend Wm. Smith, Esq. F.S.A. M.R.I., Deputy Chairman of the Trustees of the National Portrait Gallery.

A second instance of misapplied foreign portraiture occurs in the same apartment, where a full-length figure, inscribed with the name, and invested by the copyist with the arms of Queen Anne Boleyn, is in reality Anne, Queen of Hungary and Bohemia, sister-in-law of the Emperor Charles V. The execution of the portrait from which this copy had been taken was evidently German. The picture was genuine in itself; but there were dates upon it that could not possibly be made to accord with facts in English history; whereas, when applied to Mary of Hungary, everything agrees perfectly.

If, on the one hand, a rigorous investigation of the contents of many picture galleries in venerable mansions, may occasionally have the effect of depriving a portrait of lofty claims both as regards subject and on the ground of artistic merit; on the other hand, cases must also occur in which works of genuine value that had fallen into neglect, whether from accident, caprice, or dis-esteem, are rescued from unmerited oblivion, and gain reinstalment in the position due to them. The fine cartoon, by Holbein, of King Henry VIII. and his Father, hitherto undervalued, had, till recently, been hung at a great height on an obscure wall in the lofty hall at Hardwick. It has now been forwarded to the great Exhibition at South Kensington.

A portrait of a lady, in an anteroom at Windsor Castle, and inscribed on the frame 'Unknown,' I have recently had the satisfaction of assigning to 'Christina, Duchess of Milan,' the lady to whom Henry VIII. offered his hand in marriage, and who sent him the memorable message in reply, that "as she had only one head she could not oblige him." This little picture proved, on further investigation, to be the one painted in the short space of three hours by Holbein, at Brussels, whither he had been despatched by the king for that express purpose in 1538.*

The valuable drawings by Holbein, studies of the heads of the chief nobility and most eminent persons about the court of Henry VIII., were subjects deserving of the most careful study. They were admirably preserved, and had recently gained much of their original freshness by judicious cleaning, and by being remounted on separate sheets, under the scrupulous care of the librarian at Windsor. Several of the names could still be traced on them in early characters; but a more recent hand, probably that of Vertue, had inserted larger and not always suitable names and titles in golden letters, which maintained an undue prominence. Thus, many of the persons belonging to the family of Sir Thomas More, who formed subjects among these drawings, and were recognizable as such by the various paintings which existed of the More family at Nostall, and elsewhere, were deprived of their true appellations. The comparatively modern writing upon the Holbein drawings had given them very different titles and occupations. Elizabeth Dancey, daughter of Sir Thomas, was styled 'The Lady Barkley;' and his adopted daughter 'Margaret Clement,' was changed into 'Mother Jack, nurse to King Edward the Sixth.' On the other hand, two unnamed ladies in this series, heads full of character, and exquisitely drawn, are clearly 'Cicely Heron,' another daughter of Sir Thomas, and 'Anne Cressacre,' the young lady betrothed to his son. The figure called 'Lady Heneghan,' closely resembles that of Margaret Roper, in Holbein's original sketch for the subject, still preserved at Basle. Instances of this nature may not unfairly be ranked under the denomination of curiosities as well as fallacies.

---

* The original picture, by Her Majesty's gracious permission, was exhibited in the Lecture Theatre this evening, together with a choice selection of Holbein's original drawings from the portfolios at Windsor, which, by the same gracious leave, had been conveyed, under the care of B. B. Woodward, Esq., Her Majesty's librarian at Windsor Castle.

Large private collections of portraits exist in this country, but they can only be seen under circumstances of considerable difficulty. The establishment of a National Portrait Gallery—founded in 1857 at the instance of Earl Stanhope—cannot fail to become a source of pleasure and instruction to multitudes, and, in proportion as the collection increases, to afford extensive facilities for study and comparison, wherein the chief benefit of such an institution will consist. In 1820 the British Institution first afforded the public an insight into some of the portrait treasures hitherto known only by means of Houbraken's beautiful, although not always accurate or authentic, engravings. Above 183 of the finest and most genuine portraits were then collected for exhibition in Pall Mall.*

In 1846 the experiment was repeated with a greater number of portraits, but not with commensurate success.

The most striking collection of this nature hitherto seen, was the extensive Portrait Gallery formed in the central nave of the Manchester Exhibition, in 1857. Under the able management of Mr. Peter Cunningham, 400 portraits, exclusive of miniatures and full-lengths in he ancient and modern picture galleries, were there collected and judiciously arranged.

Great expectation is now naturally raised by the preparation of a portrait exhibition on a vast scale at the South Kensington Museum, under the presidency and powerful interest of the Earl of Derby.

The present discourse, being in a great measure only an introductory lecture to a short course announced to be given about the middle of the following month, all special investigation of the portraits of Mary

---

* The publication of Lodge's 'Portraits of Illustrious Personages of Great Britain,' in 1821-34, formed in itself a marked era in our acquaintance with historical portraits. With the exception, perhaps, of Queen Catharine Parr, John Knox, and Lord Falkland, they were almost all taken from the best sources, and the inscriptions upon the plates generally stated the name of the artist, when known, and the locality from which each portrait had been taken.

Queen of Scots, the Queens of Henry VIII., Shakspeare, and Milton, will be reserved for that occasion.

[The lecture was further illustrated by a large series of very fine engraved portraits, accompanied respectively by rare holograph letters and autographs of great historical value. Many of these engravings were of extreme rarity, and in the finest possible state. The collection was arranged in the library, and entirely contributed by John Young, Esq., F.S.A., of Blackheath.]

[G. S.]

GENERAL MONTHLY MEETING,

Monday, March 5, 1866.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

Charles Joseph Hyde Allen, Esq.
George Acland Ames, Esq.
John Boyle Barry, Esq. M.R.C.S.
Edward Ladd Betts, Esq.
Mrs. Katherine Sophia Elizabeth Foote.
James Park Harrison, Esq. M.A.
Mrs. Elizabeth Mary Hopgood.
John Mortimer Hunt, Esq.
Sir James Lacaita.
Sir Charles Nicholson, Bart.
Brinsley de Courcy Nixon, Esq.
J. Bertrand Payne, Esq. F.R.G.S.
Joseph Payne, Esq.
Sir Samuel Morton Peto, Bart. M.P.
David Trail Robertson, Esq.
Pandeli Ralli, Esq.
James Graham Stewart, Esq.
Daniel Charles Stiebel, Esq.
William Castle Smith, Esq.

were *elected* Members of the Royal Institution.

The Rev. John Henry Ellis, M.A.

was *admitted* a Member of the Royal Institution.

The Special Thanks of the Members were returned to the Donors of the following additions to "The Donation Fund for the Promotion of Experimental Researches" (*see* page 151):—

Captain Douglas Galton, C.B.	£10	0	0
Harry Mackenzie, Esq. (*3rd donation*)	10	10	0
Samuel Reynolds Solly, Esq. F.R.S. (*4th annual donation*)	20	0	0
Adam Murray, Esq. (*2nd donation*)	5	5	0

The decease of William Thomas Brande, Esq. D.C.L. F.R.S. L. & E. &c. Honorary Professor of Chemistry in the Royal Institution, was announced. [Mr. Brande was elected Professor of Chemistry in 1813, and Honorary Professor in 1852.]

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same:—

From
Secretary of State for India—Bombay Magnetical and Meteorological Observations for 1863. 4to. 1864.
Postmaster-General—Eleventh Report. 8vo. 1865.
Actuaries, Institute of—Index to Assurance Magazine. Vols. I.-X. 8vo. 1864.
Astronomical Society, Royal—Monthly Notices, 1865-6. No. 3. 8vo.
British Architects' Institute, Royal—Sessional Papers, 1865-6. Part II. No. 1. 4to.
Catalogue of Library. 4to. 1865.
Cator, C. O. F. Esq. M.A. M.R.I. (the Author)—Meteorological Diagram showing the Daily Elements for London for 1865.
Chemical Society—Journal for Jan. 1866. 8vo.
Editors—American Journal of Science, Jan. 1866. 8vo.
Artizan for Feb. 1866. 4to.
Athenæum for Feb. 1866. 4to.
Chemical News for Feb. 1866. 4to.
Engineer for Feb. 1866. fol.
Geological and Natural History Repertory for Feb. 1866.
Horological Journal for Feb. 1866. 8vo.
Journal of Gas-Lighting for Feb. 1866. 4to.
Mechanics' Magazine for Feb. 1866. 8vo.
Pharmaceutical Journal for Feb. 1866.
Practical Mechanics' Journal for Feb. 1866. 4to.
Geographical Society, Royal—Proceedings, Vol. X. No. 2. 8vo. 1866.
Geological Institute, Royal, Vienna—Jahrbuch, Band XV. No. 3. 4to. 1865.
Geological Society of Ireland, Royal—Journal, Vol. I. Part 1. 8vo. 1865.
Horticultural Society, Royal—Proceedings, 1866. No. 1, 2. 8vo.
Linnean Society—Journal and Proceedings, Botany. No. 36. 8vo. 1866.
Manchester Free Library—Catalogue, by A. Crestadoro. 8vo. 1864.
McEvoy, John, Esq. (the Author)—A Free Inquiry into the Irish Education Question. (K 92) 8vo. 1866.
Medico-Chirurgical Society, Royal—Proceedings, Vol. V. No. 3. 8vo. 1866.
Meteorological Society—Proceedings, No. 22. 8vo. 1866.
Photographic Society—Journal, No. 166. 8vo. 1866.
Royal Saxon Society of Sciences—Transactions. Seven Parts. 8vo. 1864-5.
Proceedings. Three Parts. 8vo. 1864-5.
Royal Society of Literature—Transactions, Vol. VIII. Part 2. 8vo.
Royal Society of London—Proceedings, No. 81. 8vo. 1865.
Ryan, Matthew, Esq. (the Author)—The Theory of Parallels. (K 92) 8vo. 1866.
Upsal Royal Society of Sciences—Upsala Universitets Arsskrift. 1864. 8vo.
Nova Acta Regiæ Societatis Scientiarum Upsaliensis Seriei Tertiæ Vol. V. Fasc. 2. 4o. 1865.
Vincent, Benjamin, Assistant Secretary and Keeper of the Library, R.I. (the Editor)—Haydn's Dictionary of Dates. 12th edition. (Two copies) 8vo. 1866.
Viquesnel, M. Auguste (the Author)—Coup d'Œil sur l'Histoire Générale des Peuples Slaves. Lyon. 8vo. 1865.

WEEKLY EVENING MEETING,

Friday, March 9, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

Sir John Lubbock, Bart. F.R.S. M.R.I.
Pres. Ent. Soc. V.P. Lin. Soc. V.P. Ethn. Soc. F.S.A.

On the Metamorphoses of Insects.

The subkingdom Annulosa, to which insects belong, is divided into five classes, namely, Annelida, Crustacea, Arachnida, Myriapoda, Insecta.

The Annelida, or worms, have a body consisting of more or less numerous segments, but without any jointed appendages.

The Crustacea, or crabs and lobsters, have a jointed body, and each segment usually bears a pair of appendages. They are aquatic in their habits.

The Arachnida, or spiders, possess four pairs of legs; the body is divided into two parts, the cephalothorax and abdomen. The segments composing the abdomen bear no appendages. Spiders are aërial in their habits.

The Myriapoda, or centipedes, have a long body consisting of numerous segments, each of which bears a pair of legs.

The Insecta, or insects, have three pairs of legs. They are aërial in habits, and breathe by means of tracheæ or air-tubes, which ramify throughout the internal organs. The body is divided into three parts, the head, thorax, and abdomen.

In addition to the three pairs of legs, the thorax bears generally either two or four wings. The older naturalists collected the wingless forms into a special order—the Aptera; but more extended observations have shown that each of the large orders or groups into which insects are divided contain some apterous forms. The female glow-worm and the working ants are familiar examples of this.

But though the presence of wings is the rule, and the division of insects into orders is founded in great measure on the characters afforded by these important organs, still they are present only in the mature state of the animal, and no known insect is born with wings.

Not only in the absence of wings, but also generally in many other important points, the young insect differs from the mature form, and the changes which it goes through are known as metamorphoses. Entomologists have generally considered the life of all insects to be divisible into four well-marked periods—that of the egg; the larva or caterpillar; the pupa or chrysalis; and, finally, the imago or perfect insect. It is true that in some orders, as, for instance, the Coleoptera (beetles), Hymenoptera (bees), Lepidoptera (butterflies), and Diptera (flies), the larvæ differ much more from the perfect insects than is the case in others, as, for instance, the Orthoptera (grasshoppers), or Heteroptera (bugs); but even in these latter the stages were still supposed to be well marked—that of the larva, by the entire absence of wings; that of the pupa, by the possession of rudimentary wings; finally, the perfect insect, by having perfect wings.

The lecturer then pointed out that, when the habits were alike, similar larvæ might be met with in very different families of insects. Thus, among beetles, the Melolontha (cockchafer), Anobium (deathwatch), and Chlamys are very similar in their larva state, although they belong to perfectly distinct families of beetles, namely, the Melolonthidæ, Ptinidæ, and Chrysomelidæ.

The same fact holds good even in larvæ belonging to different orders of insects. Those larvæ which, in the words of Mr. Herbert Spencer, are "symmetrically related to the environment," and which either are surrounded by their food, or which have it brought to them, are fat, legless, fleshy grubs or maggots. Such are almost all the larvæ of flies. So again, the Hymenopterous larvæ are generally of this character; whether they inhabit other insects, like those of the ichneumons; or live inside galls, like those of the Cynipidæ; or are enclosed in cells and fed by the perfect insects, like those of the bees; practically any great deviation from that which may be looked upon as the normal type, is unnecessary. The larvæ of beetles, on the contrary, are generally of a very different character. But there is one group, that of the weevils, which are internal feeders. The grub of a nut-weevil feeding inside a nut, is under very similar conditions to those of a Cynips-larva in a gall, or an Anthrax-larva living parasitically in a bee's cell, and we accordingly find that these larvæ, though belonging to three different orders of insects, very closely resemble one another.

To this type belong most Hymenopterous larvæ; but there are two exceptional groups, the Tenthredinidæ, or sawflies, and the Siricidæ. The larvæ of the Tenthredinidæ feed, like those of butterflies, on leaves, and in the general form of the body, in the possession of three pairs of legs and several pairs of abdominal prolegs, they very closely resemble ordinary caterpillars, and differ extremely from the ordinary type of Hymenopterous larvæ. In the same manner the larvæ of the Siricidæ, which are wood-borers, possess thoracic legs, and closely resemble the larvæ of some wood-boring beetles.

From these facts it may be concluded that the form of a larva depends more on the conditions in which it lives than on the form which it will ultimately assume. But this is shown still more clearly in the case of Sitaris, a small beetle which is parasitic on a species of solitary bee

(Anthophora), and the habits of which have been carefully observed and excellently described by a French naturalist, M. Fabre. The female Sitaris, which comes to maturity in August, never wanders far away from the sandy banks in which the Anthophora loves to burrow. At that time no Anthophoras are abroad, their period of maturity is not in autumn, but in spring, and consequently, though the bee is so necessary to the beetle, we are at once met with the remarkable fact that no perfect Sitaris ever saw one of the bees, and it is probable that no Anthophora has ever yet seen a Sitaris. The latter lays her eggs, which are about 2500 in number, in the burrow leading to the cell of the Anthophora. These eggs are hatched in September, and produce small, black, active larvæ, about 1-25 of an inch in length, with four eyes, two rather long antennæ, and six well-formed legs. But though evidently adapted for an active life the young larvæ remain quiet among their empty egg-shells until the spring. Then the Anthophora comes to maturity, and as it passes out along the burrow the young larvæ spring upon it. The male bees, however, leave their cells about a month before the females; consequently the larva first finds itself on the male bee, from which, however, at the first opportunity it passes to the female. She, poor thing, unconscious of her misfortune, proceeds to excavate her burrow in the usual manner, constructs the usual cell, and fills it with honey. On the honey she lays her egg, but at this moment the larva of Sitaris springs on to the egg and floats on it, as on a raft. It then tears open the egg and devours it, thus at once destroying a rival, and making its first meal. As it has by this time been seven months without food, this its first food must be very welcome. But it is necessary on another account. The larva in its first form, though beautifully fitted for its mode of life, is quite unsuited to live on honey in a bee's cell. Hence a change of form is necessary. The increase of size produced by devouring the egg enables the larva to change its skin, and it now emerges in a form very different indeed from the last. The eyes have disappeared, the legs and antennæ are rudimentary. The mouth is so placed that when the larva floats on the honey it is just below the surface, while the spiracles are arranged along the back so as to be just above it. Lastly, the belly is very protuberant, and thus prevents the larva from rolling, in which case the spiracles might be choked by the honey, and the insect suffocated. After living from thirty-five to forty days in this condition, during which it increases very considerably in size, the larva ceases to feed, and contracts into an ovoid body, resembling in many respects the so-called pupa of a fly. Within this, as in a case, it forms a new skin, and takes on a fourth form not very unlike the second. After four or five weeks it changes again into a chrysalis, from which finally the perfect beetle emerges.

Here then we find, firstly, a remarkable change of form accompanying a change of habits, and secondly, a case in which the life is divided into more than three well-marked stages. This phenomenon received from M. Fabre the name of Hypermetamorphosis. For some time the cases of Sitaris and Meloe were looked on as exceptional; but in 1862 the attention of the lecturer was called to the question by observing a somewhat similar case in Lonchoptera, a genus of small flies. Moreover, he found that in many species belonging to the Orthoptera and Hemiptera the stages were much less definite and more gradual than had hitherto been supposed.

In illustration of this he described the transformations of Chloëon (Ephemeridæ), and showed that the perfect form was attained through more than twenty changes of skin, each attended by a slight change of form. In its preparatory stages this insect lives in the water, but in the last two it becomes aërial. Sir John Lubbock had been so fortunate as to see more than once the passage from the aquatic to the aërial condition; the larva floated helplessly on the surface of the water, suddenly the skin burst, the insect sprang out of the back of its own head and fluttered away. The whole process occupied less than ten seconds.

The speaker in this case wished particularly to impress on his hearers, firstly, the gradual nature of the changes, and secondly, that some of them have no reference to the form of the perfect insect, but are entirely of an adaptational character. Thus, the young larva is born without branchiæ, and with two caudal appendages. It gradually acquires a thin tail and seven pairs of branchiæ, but the perfect insect has only two tails and no branchiæ. Thus, then, the changes which an insect undergoes are of two kinds, developmental and adaptational.

External forces act upon the larvæ as much as on the perfect insects. And we can thus understand the remarkable fact that some animals, which differ much when young, are very similar at maturity.

The speaker then entered into some theoretical considerations as to the nature and causes of metamorphoses, dividing the subject into three questions.

1stly. How these changes of form might have originated.

2ndly. Why they are, in insects, so abrupt in their character; and

3rdly. Why the pupa condition, a period of approximate immobility, should intervene between the active larva, and the still more active imago.

1. The changes of form depend on the early condition at which some insects quit the egg. There is reason to believe that all insects pass through the stage of fat, fleshy grubs, and subsequently acquire legs.* Some, however, are hatched in the first state, while others remain in the egg until they attain the second. In the former case additional changes are produced by the fact that external forces do not affect the larva in the same manner as the perfect insect; and thus there is a tendency to still greater differentiation.

2. The abruptness of the change is more apparent than real. The actual change itself is merely the withdrawal of the curtain, the casting

---

* See, for instance, Professor Huxley's admirable memoir on Aphis, in the 'Linnean Transactions.'

of the old skin, by which the alterations which have perhaps been in preparation for days or even weeks, are rendered visible. In fact, there can be no great change in insects without a moult. Insects have no bones, and the muscles are attached to the skin, which therefore is necessarily hardened to afford them a solid and sufficient fulcrum. But it follows from this that no change of form can take place without a change of skin.

In Chloëon we have seen that each moult is accompanied by a slight change.

In caterpillars, on the contrary, there is little alteration during growth, and the changes are concentrated, so to say, on the last two moults. The advantage of this is obvious; the mouth, digestive, and other organs of the larva are very different from those of the perfect nsect; and if the change from the one type to the other were gradual and slow, the insect would be liable to perish of starvation in the midst of plenty.

3. Similar considerations throw much light on the immobility of he pupa. The organs are altering so rapidly that they are unable to perform their functions. When the changes are gradual, as in Orthoptera, &c., there is no period of quiescence.

The speaker then pointed out the analogy between metamorphoses nd the alternation of generations.

Many species of the lower animals are represented by two totally issimilar forms; but, so far as the speaker knew, no explanation of his remarkable phenomenon had yet been given.

Through the metamorphoses of insects, however, we get a clue. When an animal is born in a state so early, that external forces act on it in one way, and on the perfect form in another, they tend to produce greater and greater differences between the two. As long as the xternal organs arrive at their mature form before the generative rgans are fully developed, we have cases of metamorphosis; but if the everse is the case, then alternation of generations is the result.

The same considerations explain why in alternation of generations he reproduction is almost invariably agamic in the one form. This is ecause impregnation requires the perfection both of external and internal organs; and if the phenomenon arises, as has just been suggested, from the fact that the internal organs arrive at maturity before he external ones, impregnation cannot take place, and reproduction will only result in those species which have the power of agamic multilication.

However this may be, insects offer every gradation between simple rowth and that phenomenon which is known as alternation of generaions.

In the wingless Orthoptera, the young so closely resemble the perfect insects, that there is nothing which in ordinary language would e called even a metamorphosis.

In those Orthoptera which eventually acquire wings, there is of course well-marked difference.

In Chloëon, though the changes are gradual, the difference between the larva and the imago is very considerable, and we have seen that the action of external forces produces changes which have no reference to the form of the perfect insect.

In caterpillars we have a typical class of metamorphoses.

Until recently, however, we knew of no case in which a larva produced more than one perfect insect.* Insects never multiply by buds, and almost always the external form is acquired before the organs of reproduction are mature. Recently, however, Professor Wagner of Kasan has discovered that the larvæ of certain Cecidomyias have the faculty of producing other larvæ, so that they present a true case of alternation of generations. Thus, then, we see that insects present every gradation from growth to alternation of generations; we see how, from a single fact, metamorphoses and alternate generations may have originated, and we find reason to suppose that in the course of time the latter phenomenon may become more frequent than it is at present.

It is, moreover, evident that there are in the animal and vegetable kingdoms two kinds of Dimorphism. The term has generally been applied to those cases in which—as in the ant and bee, in animals, and the Primulas among plants—the perfect individuals are divided into two forms. In fact, the sexes themselves constitute a kind of Dimorphism. In these cases the forms are not alternate. When, however, external forces act on the young in one manner, and on the mature form in another, they tend to produce different forms, which do not complement, but succeed, one another. I have elsewhere proposed to distinguish this form of dimorphism, under the name of Dieidism or Polyeidism. In Polymorphism the chain of being divides at the extremity; in Polyeidism it consists of dissimilar links.

Finally, the speaker said :—" The principal conclusions which I would impress on you this evening are :—

" 1. That the presence of metamorphoses in insects depends, in great measure, at least, upon the early state in which they quit the egg.

" 2. That metamorphoses are of two kinds—developmental and adaptational.

" 3. That the apparent abruptness of the changes which they undergo arises in great measure from the hardness of their skin, which permits no gradual alteration of form, and which is itself rendered necessary in order to afford sufficient support to the muscles.

" 4. That the immobility of the pupa or chrysalis depends on the rapidity of the changes going on in it.

" 5. That although the majority of insects go through three well-marked stages after leaving the egg, still a large number arrive at maturity through a somewhat indefinite number of slight changes.

---

* The instances in which certain insects breed while their wings are but imperfect, might here have been cited. But as there is much difference of opinion among entomologists as to these cases, I have thought it better to take one about which no question is likely to arise.

" 6. That the form of the larva of each species depends in great measure on the conditions in which it lives.

" When an animal is hatched from the egg in an immature form, the external forces acting upon it are different from those which affect the mature form, and thus changes are produced in the young, bearing reference to its present wants rather than to its ultimate form.

" 7. When the external organs arrive at this final form before the organs of reproduction are matured, these changes are known as metamorphoses; when, on the contrary, the organs of reproduction are functionally perfect before the external organs, or when the creature has the power of budding, then the phenomenon is known as alternation of generations.

" Insects present every gradation, from simple growth to alternation of generations.

" 8. Thus, then, it appears probable that this remarkable phenomenon may have arisen from the simple circumstance that certain animals leave the egg at a very early stage of development: and that the external forces acting on the young are different from those which affect the mature form.

" 9. The dimorphism thus produced differs in many important respects from the dimorphism of the mature form which we find, for instance, in the ants and bees; and it would therefore be convenient to distinguish it by a different name.

" But there is still another aspect under which, if time had permitted, the metamorphoses of insects might have been regarded. In one or two cases, indeed, I have sketched very briefly and imperfectly the habits and mode of life of particular insects. A whole course of lectures might be filled with such life histories. The various manners in which different insects provide for the wants of their young are most remarkable; and all the more so because these wants are so different from those of the perfect insects themselves.

" Thus, the butterfly which lives on honey, and did live on leaves, lays her eggs on a twig. She seems to feel that honey will not suit her young, and that the leaves will wither and fall before another spring comes round.

" The gnat, which lives in the air and feeds on blood, lays her eggs on the surface of water; and the sugar-loving housefly knows that very different food is necessary for her young.

" The nut-weevil chooses the embryo of the nut; the goat-moth the bark of the willow; the Rhipiphora braves the dangers of the wasp's nest; the Œstrus lays on cattle; the Ichneumon in caterpillars; the gall-fly in the still almost imperceptible bud; and some insects even in the eggs of others.

" Generally, the larvæ forage for themselves; but, in some cases, the mother supplies her young with food. Thus, the solitary wasp builds a cell and fills it with other insects. If, however, she imprisoned them while alive, their struggles would infallibly destroy her egg; if she killed them, they would soon decay, and the young larva, when hatched, would find, instead of a store of wholesome food, a mere mass of corruption. To avoid these two evils, the wasp stings her victim in such a manner as to pierce the centre of the nervous system, and the poison has the quality of paralyzing the victim without killing it. Thus deprived of all power of movement, but still alive, it remains some weeks motionless and yet fresh.

" But, perhaps the ants are the most remarkable of all. They tend their young, they build houses, they make wars, they keep slaves, they have domestic animals, and it is even said that in some cases they cultivate the ground.

" Nor must it be supposed that even now the habits of insects are anything like thoroughly known to us. In spite of Reaumur and De Geer, the two Hubers, and many other excellent observers, there is in this subject still a wide field for patient and conscientious labour; the observations already made have been far from exhausting the mine, though amply sufficient to prove the richness of the ore."

[J. L.]

WEEKLY EVENING MEETING,

Friday, March 16, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

Balfour Stewart, Esq. F.R.S.

On the Existence of a Material Medium pervading Space.

The question, whether interstellar and interplanetary space is a plenum or a vacuum, has for a long time engaged the attention of the scientific world.

As we can hold no communication with these distant regions, except through the light which reaches us, it is to this agent we must look to enable us to answer this question directly or indirectly, either from its own properties and nature, or from its faculty of revealing to us the position and motion of the heavenly bodies, or from both of these together.

This twofold aspect of the problem gives rise to the following questions:—

Question first.—Does the nature of light and radiant heat induce us to believe that space is a plenum or a vacuum?

Question second.—Is there anything in the motions of the heavenly bodies that gives us any information on this point?

These two questions comprise the observational evidence on the subject.

By observational, as distinguished from experimental, we mean evidence derived from a region where we may observe what is going on, but into which we cannot transport ourselves so as to make any experiments; besides this evidence we may moreover make experiments on the surface of the earth in our laboratories, and derive from these experiments a certain amount of information bearing upon our question.

We have thus altogether three sources of evidence.

First.—Evidence derived from the nature of light and heat.

Second.—Evidence derived from the motion of the heavenly bodies.

Third.—Experiments made on the surface of the earth.

Possibly also the force of gravitation which is exercised by bodies at a distance, and the connection between solar spots and terrestrial magnetism, discovered by General Sabine, imply the existence of an interplanetary medium; but it is better to confine ourselves to light and heat, which differ from other influences in this respect. We know that light and heat travel with a certain velocity, and we can suppose, as it were, a slice of light to be cut off half-way between the sun and the earth; here then we have a certain amount of energy neither in the sun nor in the earth, but half-way between; we cannot, however, at present, make any such assertion with regard to gravity or magnetic action.

To begin with the evidence derived from the nature of light and heat.

It is supposed by some (or rather perhaps it has been supposed, for the advocates of this theory are dying out) that light consists of exceedingly small particles which are projected into space by a luminous body on all sides, particles having different properties, but all of which, nevertheless, pass through interplanetary space with the same enormous velocity of 190,000 miles per second. On the other hand it is supposed that light consists in the transmission of some sort of motion of a medium pervading all space.

The difference between these two hypotheses may be explained in a very few words.

The theory of emission supposes the transit of an individual particle from the luminous body to the eye; the theory of undulation or similar theory, on the other hand, merely supposes the progressive motion of a state of displacement between the luminous body and the eye. (Illustrated by an experiment.)

Thus, according to the former theory, each ray of light which passes between the sun and the earth is equivalent to the bodily transmission of a set of particles 90,000,000 of miles; while, according to the theory of undulation, the greatest amount of relative displacement of the ether whose vibrations form this ray, is probably much less than the millionth of an inch.

Now, the difference between these two modes of viewing light as concerns our subject is this:—

The existence of an ethereal medium does not appear to be inseparably connected with the first theory or that of emission. The two ideas may be held and have been held together, but they do not appear to be inseparably connected; on the other hand, if light and heat consist of the transmission of some sort of motion of a medium pervading space, we have to start at once with the hypothesis of such a medium. Hooke and Huyghens were the scientific authors of the undulatory theory of light, while Newton, on the other hand, was the great advocate of the theory of emission.

The scientific repute of Newton seems to have retarded the progress of the undulatory theory for nearly a century; but of late years it has been revived and extended in this country by Young, whose name is inseparably connected with the Royal Institution, and in France by the illustrious Fresnel. It is only by an appeal to experiment that we can decide between the claims of these two rival theories, and we have to ask ourselves which best accords with the phenomena of optics.

First of all, if we assume the hypothesis of emission, it is not easy to conceive why the luminiferous particles discharged by so many different kinds of bodies should all pass through space with precisely the same velocity. In order to escape from this difficulty, it was suggested by Arago that particles may be originally projected with different velocities, but that there is only one of these which is adapted to our organs of vision. This, however, is a very lame explanation, and the necessity for such explanations is one of the characteristics of a bad hypothesis. For if a theory be good, it is wonderful how many facts it will account for without any additional assumption, but a bad hypothesis requires to start an additional assumption for almost every new fact, until at length some one arises which cannot be won over by even this method, and so the hypothesis fails.

In the next place, it is difficult to conceive why particles, which although exceedingly small, moving with such enormous velocity, should not inflict on us terrific blows on account of their momentum; and it has been calculated that if the weight of a molecule of light amounted to but one grain, its momentum would equal that of a cannon ball 150 pounds in weight moving with a velocity of 1000 feet per second.

Even although a molecule of light should be many million times smaller than this, its momentum would still be sensible; and as millions of millions must enter the eye every instant from every visible point of every visible body, we should be pounded to atoms.

A good many years ago, Mr. Bennet made some experiments on this point. A slender straw was suspended horizontally by means of a spider's thread, and to one end of this lever a small piece of white paper was attached, and the whole was enclosed in an exhausted receiver of glass, while the sun's rays, concentrated by a large lens, were allowed to fall on one side of this paper; but they did not twist round the lever in the least.

The advocates of the theory of emission may perhaps, however, suppose that they are entitled to make the light molecules, and hence their momentum, as small as they choose, and of course, if this be allowed, even the most delicate experiment will not be decisive. But a short explanation will show that they are not entitled to make the momentum of a ray of light as small as they choose, but that the theory of the conservation of energy which has been elaborated by Grove, Joule, Thomson, and others, and is now universally accepted, determines this momentum.

Of course one who denies the undulatory hypothesis may, at the same time, deny the conservation of energy—we have nothing to say to such an one; but we think it can be proved that one cannot at the same time hold both the theory of emission and the theory of the conservation of energy.

In order to show this, let us suppose that such a man exists, believing the theory of the conservation of energy, but denying the undulatory hypothesis, and advocating in its stead the theory of emission. Now, in the first place, the amount of *momentum* or the *blow* which a body is capable of giving must be distinguished from the *energy* which it possesses. Thus, if we fire a rifle-bullet so as strike an iron target (swung by a string) and lodge in it, this target or pendulum will be swung to a side on account of the momentum or blow of the ball. But as far as momentum is concerned, when a rifle is discharged, action and reaction are equal, so that the momentum of the ball is no greater than that of the recoiling rifle; and hence, if the rifle were swung, attached to another pendulum, the recoil of the rifle would produce the same effect as the ball in the first pendulum. (Illustrated by an experiment with a small cannon.)

But the ball does something more than swing the pendulum, it ultimately heats it; and, in fact, this amount of heating forms very much the energy of the ball.

Now energy is known to be proportional to the momentum or blow multiplied by the velocity, and hence it is owing to its high velocity that a rifle-ball possesses so much energy. Let us now return to Bennet's experiment, in which a powerful beam of light was made to strike a piece of paper fastened to the end of a straw, delicately suspended in the centre by a spider's thread. By the theory of the conservation of energy, we know that the energy of the light and heat which strike the paper in one minute, will, just as in the case of the rifle-ball, be represented by the whole heating effect produced.

Now we can roughly estimate this heating effect, and we can therefore find the amount of energy produced by these rays in one minute, and knowing the amount of energy, we can tell at once the *blow multiplied by the velocity* to which the energy is proportional. We therefore know the *blow multiplied by the velocity* of the light, but we also know the *velocity*; hence, dividing the first by the second, we know the blow which the light ought to produce in this arrangement, if we suppose the theory of emission to be true. By a rough calculation it may be shown that the blow ought to be sensible, but Bennet found it to be insensible, hence we argue that the theory of emission is not true.

The experiment performed by MM. Foucault and Fizeau was then described. This experiment proves that light travels slower in water than in air, and this result is also in favour of the undulatory theory, but against that of emission.

Finally it was stated, that a great number of beautiful and interesting optical experiments can be explained with the greatest ease by the theory of undulations. (Through the kindness of Professor Tyndall a selection of these was exhibited.)

All these various proofs are in favour of the undulatory theory of light, and we have therefore great reason to believe in its truth, and, believing in it, we are compelled also to believe in the existence of a material medium in which these undulations may take place.

We now come to discuss the second branch of our subject, or the evidence derived from the motions of the heavenly bodies, and as yet there is only one of these that has afforded us evidence of the existence of an ethereal medium.

In November, 1818, M. Pons, in Marseilles, discovered a comet, which M. Encke, in Berlin, after calculating its elements, found to be identical with the comets seen in 1786, 1795, and 1805. In comparing the different observations, he immediately noticed a steady decrease in the duration of the comet's revolution. M. Encke conceived that some permanently retarding force must influence the motion of the comet; but the nature of that force would only be cleared up by continuous and very carefully conducted observations at each return. Consequently, in 1819, he called the attention of astronomers to this comet; but the whole of the subsequent observations, and the calculations founded upon them, were not discussed until forty years had elapsed. M. Encke, in his first discussion, obtained the following results:—

(*a.*) It is impossible by the laws of planetary motion to explain the motion of this comet.

(*b.*) The whole period of revolution has been shortened since the first observation in 1786 by two days and eight hours, which, in proportion to its small period of revolution (about 1210 days), is far too large an amount to ascribe it to imperfections of the observations or of the instruments.

(*c.*) The amount of decrease is at each revolution constantly the same, and so regularly observed at each return of the comet to its perihelion that not the least doubt now exists as to the fact itself.

(*d.*) The mathematical consideration of the nature of the retarding force shows it to be *entirely* a tangential force, that is, such a force as is always exerted by a medium filling space where a body is in motion; it follows, that we are led to assume the existence of a medium filling all space, and producing effects analogous to those observed on our earth. This is, says M. Encke, not an artificial assumption, but the force is immediately suggested from the nature of its effects.

An experiment made by the speaker in conjunction with Professor Tait was then described. This experiment was carried out by means of an ingenious mechanical contrivance invented and made by Mr. Beckley, of the Kew Observatory. The object of the experiment was to produce very rapid rotation in vacuo. This was accomplished by carrying a slowly revolving iron shaft up a barometer tube; at the top of this tube there was a large receiver, which might be considered analogous to the vacuum of a barometer, with the exception that it was exhausted by an air-pump, and not by the Torricellian process. In this receiver, by means of multiplying gear connected with the shaft, an aluminium disk, 13 inches in diameter and $\frac{1}{10}$th of an inch in thickness, was made to revolve with great velocity. When it was kept for 30 seconds at the full speed of 83 revolutions in a second, this disk was found to become heated nearly 1° Fahr., and this heating was independent both of the density and chemical constitution of the residual air of the vacuum.

The disk was insulated from its bearings by a piece of ebonite, so that very little heat could be conveyed from the bearings to the disk; besides, an experiment made by artificially heating the spindle showed that the effect observed could not be due to heating of the disk by the bearings. This heating effect, it was believed, was not due to rotation under the earth's magnetic force, nor to vibration of the disk; but the experiment was not quite finished: in the meantime, the evidence that it could not be explained by any known cause was very considerable, so that perhaps an explanation may be sought for in a resisting medium which we cannot get rid of.

[B. S.]

WEEKLY EVENING MEETING,

Friday, March 23, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

Henry Bence Jones, A.M. M.D. F.R.S. Hon. Sec. R.I.

On the existence in the textures of Animals of a Fluorescent substance closely resembling Quinine.

When I last year brought to your notice the fact that "a single dose of lithium in a few minutes passes, through the circulation, into all the ducts, and into every particle of the body, and even into the parts most distant from the blood circulation, and when I showed you that it remains there for a much longer time than it took to get into the textures (probably for three or four days, varying with the quantity taken), and that then it diminishes, and finally, in six, seven, or eight days, the whole quantity is thrown out of the body," I little expected that by prosecuting an investigation into this chemical circulation in the body I should come upon that discovery which forms the title for this evening's discourse.

No imagination could have anticipated that this line of research into the rate of passage of substances into and out of the textures would lead to the supposition that man and all animals possess, in every part of the body, the most characteristic peculiarity of the bark of the cinchona trees of Peru.

After determining the rate of passage of lithia and other mineral matters into and out of the body, Dr. Dupré and I proceeded to endeavour to trace the rate of passage of quinine into and out of the textures of animals.

We chose quinine because of that splendid test which led Professor Stokes to the discovery of the change of refrangibility of light.

Here, for example, are different solutions of quinine of different strengths, and by means of the production of fluorescence in the electric light, you see how we can determine which of these solutions contains the greatest quantity of quinine; and by forming standard solutions it would be easy to measure how much quinine existed in each of these solutions. Moreover, Professor Stokes discovered that when a solution of common salt was added to this quinine solution, the fluorescence entirely disappeared. Though this may be so for sun light, it does not disappear in this electric light; and, moreover, on adding a solution of sulphate of soda to a solution of chloride of quinine, the fluorescence in great measure returns.

Still further, Professor Stokes showed that one solution of quinine ntirely stopped these rays from passing into a second solution of the ame substance, so that you might almost tell whether you had a solu-on of quinine by seeing whether it cut off the fluorescence from a econd solution of quinine.

Our first object was to determine the delicacy of this reaction for uinine. We arrived at the following results, when the spark from a uhmkorff coil was the source of light:—

ulphate of quinine gave slight fluorescence when $\frac{1}{1800000}$ of a grain was present.
" " feeble " $\frac{1}{1100000}$ " "
" " distinct " $\frac{1}{1800000}$ " "

ne grain of sulphate of quinine in one million eight hundred parts of ater showed the blue fluorescence distinctly in 20 grs. of the solution. n another experiment, the same amount of quinine in one million four undred and forty-four parts of water showed fluorescence very dis-inctly.

Having thus got our test, we proceed to apply it to determine the assage of quinine into and out of the textures of guinea-pigs.

A guinea-pig was given quinine, and for comparison another uinea-pig was killed at the same time, having had no quinine.

In the pig that had taken quinine, each organ was heated in a ater-bath, with very dilute sulphuric acid. This extraction was epeated over and over again. The acid extracts were mixed and ltered after cooling, neutralized with caustic soda, and repeatedly haken up with their own bulk of ether. The residue left after vaporation of the ether, was taken up by dilute sulphuric acid, filtered nd tested for fluorescence.

The pig that had taken no quinine, had each organ treated in a recisely similar way. To our great disappointment, at first, we found hat not only had the pig that had taken quinine a fluorescent ubstance in the textures, but that an almost exactly similar substance as extracted from the organs of the pig that had taken no quinine. very texture was examined, and in every one this fluorescent ubstance occurred.

We then endeavoured, in every possible way, to find a means of eparating the natural from the induced fluorescence. And as every nethod failed, and we were compelled to recognize the close similarity f the substance that exists in the textures to quinine itself, we for a ime dropped the original inquiry, and proceeded to a more complete nvestigation of the natural fluorescent substance in animals.

Without any preparation this substance can be shown to exist in he living and in the dead textures. There is one transparent ubstance which is above all most suited for this inquiry.

Here are some lenses removed from the eyes of bullocks, guinea-igs, and man. You see how clear, white, and transparent these ubstances are; and if I take a bullock's eye, which by gentle pressure as been flattened so that the structure can be distinctly made out, there is plainly no colouring matter. As in quinine, nothing is seen until the blue rays of the electric light fall on the lenses; then look at the splendour of the reaction. Here, with the guinea-pig's lenses, the same is seen; and here, with the flattened bullock's eye. You might be tempted to think that this is a *post-mortem* change, a result of decay; but here is a fresh bullock's eye, look at this blaze of bluish-green light; but still more full of suggestion is an experiment with a dilated pupil in a living animal or in man. Let me show you my own eye, for in it you can see the lens shining with this unnatural, because unaccustomed, light, looking like an opaque substance, a blue green cataract.

Life and death then have nothing to do with the existence of this substance; here, it is present in the living lens; it does not disappear from lenses that have been kept for months in glycerine.

I have already said that this substance not only exists in the lens, but that it can be found everywhere by treating any animal substance, first with dilute acid, then neutralizing with alkali, and then extracting with ether: thus we obtain solutions having exactly the same properties as you see in the lens. Here, for example, is such an extract from the liver. Here, from the kidney. Here, from the heart. When an acid solution of this substance is treated with ether, no fluorescent substance is obtained. First, as with quinine, the acid must be neutralized before this substance or the quinine can be taken up by the ether.

Having then obtained these solutions, we were able to compare them with solutions of quinine in their actions on the spectrum. And first, the solution of the natural substance begins to fluoresce a little before the solution of quinine; but on carrying it on through the spectrum it ends where quinine ends.

The fluorescent light of the natural substance is a little more greenish than the fluorescent light of quinine.

If a quartz cell containing this fluid is interposed between the source of light and a solution of quinine, no fluorescence takes place in the quinine; and if quinine is interposed between the light and this natural solution, scarcely any fluorescence is observed in it.

When a solution of salt is added to the naturally fluorescing substance, it is almost entirely destroyed, as happens with quinine.

If the natural solution is boiled with permanganate of potass, it does not lose its fluorescence, nor does quinine; but when permanganate with excess of alkali acts upon this substance or upon quinine, the fluorescent substance is entirely oxidised.

Hence this substance by the mode of its extraction and by its remarkable action on light, is very closely related to quinine; and this led us to apply the chemical tests for quinine to this natural fluorescent substance, after extraction from the body.

The different tests for alkaloids like quinine, as morphia, strychnine veratrine, atropine, you may see in the following reactions. First, quinine gives, as you see, a precipitate with iodine in iodide of potassium. Secondly, iodide of mercury in iodide of potassium also gives a precipitate. Thirdly, phosphomolybdic acid also gives a precipitate. Fourthly, bichloride of platinum gives a precipitate. Lastly, terchloride of gold causes a precipitate, and this precipitate is soluble in alcohol.

Now each and all these different reactions are obtained with these same reagents acting on the fluorescent substance that is extracted from animals.

So that here again we have chemical proof that this substance is an alkaloid, and that it, is closely related to quinine.

We have named it Animal Quinoidine because we have not as yet been able to crystallize it nor to obtain enough for an analysis.

Having satisfied ourselves that an alkaline fluorescent substance resembling quinine existed in the different textures, we endeavoured to determine the proportion that was present in different parts. For this purpose standard solutions of quinine of known strength were prepared, and equal amounts of substance were treated in precisely similar ways, and then the fluorescence was compared with the standard solutions of quinine. No very accurate estimations could thus be made, but comparative results could be obtained, and these are represented in the following tables:—

On the amount of fluorescent substance in different parts of guinea-pigs and of man, measured by the number of grains of quinine in 100 *litres* (= 176 *pints*) *of water, that gave the same fluorescence.*

	IN GUINEA-PIGS.			IN MAN.		
Liver	6 to 3	6	2	2	2	2
Lenses	3	2	2	2		
Kidney	3	2	2	2	2	3 to 6
Urine	3	2	2			
Bile	3	2	2			
Blood	3	2	2			
Brain	3	2	2			
Nerves	3	2	2	1	1	2
Muscles	3	2	2	1	2	2
Humours of the Eye .	2	2	2			
Cartilages	..	..	..	3	1	
Spleen	..	..	..	1	1	3
Lungs	..	..	..	1	1	2

What, then, is the meaning of this widely diffused substance in animals which so closely resembles quinine? At present we are far from a perfectly clear answer. It is not thirty years yet since the presence of ammonia in the products of distillation of coal was considered "curious," because nitrogen was thought to be the characteristic of an animal substance, and absence of nitrogen was considered as the distinctive mark of vegetable creation. Gradually, year by year, each substance that has been thought to be the special property of the vegetable world has been found to occur in animals. Thus sugar, starch, woody fibre, vegetable colouring matter as indigo, albuminous substances, are common to animals and vegetables; and at length we have arrived at the fact that no distinction can truly be drawn between the three kingdoms of nature. In the body, salt and phosphate of lime and phosphate of soda are animal substances as much as fibrin and albumen. Sugar is as much an animal substance as albumen is a vegetable substance, and no separation can be made by chemical analysis between animal, vegetable, and mineral.

The processes which take place in the three different kingdoms are, however, very different. The vegetable generally from carbonic acid ammonia and water can synthetically build up acids, neutral hydro-carbons, fats, alkaloids, and albuminous substances. Whilst the animal generally from albumen analytically produces alkaloids, fats, neutral hydro-carbons, acids, and ultimately water, ammonia, and carbonic acid.

Thus the following table of synthetically and analytically produced substances common to both kingdoms may even now be formed:—

From Carbonate of Ammonia and Water. *Synthetically formed substances, by the plant or by the chemist.*	From Albumen passing down to Carbonate of Ammonia and Water. *Analytically formed substances.*
Oxalic Acid	Albumen
Formic	Casein
Lactic	Animal Quinoidine
Acetic	Indican
Valerianic	Glycocol
Glycerine	Taurin
Sugar	Leucin
Starch	Urea
Cellulose	Caprylic Acid
Cholesterin	Caproic
Butyrin	Capric
Palmatin	Olein
Stearin	Stearin
Olein	Palmatin
Capric Acid	Butyrin
Caproic	Cholesterin
Caprylic	Cellulose
Urea	Starch
Leucin	Sugar
Taurin	Glycerine
Glycocol	Valerianic Acid
Indican	Acetic
Quinine	Lactic
Casein	Formic
Albumen.	Oxalic.

From this point of view, then, our so-called animal quinoidine is descended from albumen, and its ultimate progeny are carbonate of ammonia and water, out of which substances the cinchona tree, under favourable circumstances, is able to build up quinine.

$$C_{40}\,H_{24}\,N_2\,O_4$$

From the large number of carbon atoms in quinine, it may be regarded as one of the early substances produced in the downward passage of albumen, and from this we shall very probably find the key to the question how quinine acts in the body.

When sulphate of quinine is taken, like the lithium and other substances which I brought before you last year, it rapidly passes from the blood into the textures.

Even in a quarter of an hour, after four grains of sulphate of quinine the fluorescence may rise to 75 grains to 100 litres. It is found in greatest amount in the liver and kidney; rather less in the blood, urine, and muscles; still less in the brain, nerves and bile; and is perhaps even in this time increased in the lens of the eye.

In three hours the maximum effect of the quinine may be reached. It amounts then to from 100 to 200 grains of quinine in 100 litres of water, and it occurs to this amount in the liver, kidney, urine, bile, blood, brain, and muscles. The nerves and aqueous humour showed much less increase, and the lenses showed the least increase of all the textures.

In six hours the amount of fluorescence was rather less than in three hours.

In twenty-four hours it was considerably less than half as much as in three hours.

In forty-eight hours, except in the liver and blood, there was but little more fluorescent substance in the textures than naturally exists there.

And in seventy-two hours the liver showed no trace of increase of fluorescence.

Hence, in fifteen minutes the quinine had passed everywhere. In three hours it was at its maximum, and remained in excess for six hours. In twenty-four hours it was much diminished, and in forty-eight hours scarcely perceptible.

These results were obtained by extracting the natural fluorescent substance and the quinine together from the textures, determining the joint fluorescence by standard solutions; and by comparing the numbers thus obtained with the numbers given when no quinine was taken.

The following table of the fluorescence of the different textures after four grains of quinine had been taken by guinea-pigs was made:

	Experiment 1, ¼ hour.	Experiment 2, ½ hour.	Experiment 3, 1 hour.	Experiment 4, 3 hours.	Experiment 5, 4½ hours.	Experiment 6, 5½ hours.	Experiment 7, 6 hours.	Experiment 8, 8 hours.	Experiment 9, 24 hours.	Experiment 10, 32 hours.	Experiment 11, 48 hours.	Experiment 12, 72 hours.
Liver	75	40	20 to 40	100 to 200	100		100 to 200		50	4	6	6
Lenses	6 to 3	5	..	3	2		3 „ 1		3		3	3
Kidney	75	40	20	100 to 200	100		100		50		3	3
Urine	50	20 to 10	20	100 „ 200	100		100	4 to 6	12 to 6	2	3	3
Bile	12	20	5	100 „ 200	13		75	5	12		3	3
Blood	50	20	20	100 „ 200	12 to 25	20 to 40	100 to 50		12		6	3
Brain	12	10 to 5	5 to 3	100 „ 200	6 „ 12		25		6			3
Nerves	6	5	least	6	2		6		3		3	3
Muscles	50 to 25	20	5	100 to 200	50 to 100		25		12 to 6		3	3
Humors	..	5	..	6 to 3	2		3		6		3	least

We have been able also to find some trace of the passage of the quinine even into the lens of the eye of man.

The following table, which we owe to the kindness of Mr. Bowman, who gave us the cataracts, makes this evident :—

On the increase of fluorescence in cataracts after quinine.

Natural fluorescence of lens	=	1·6	grs. of quinine per	100 litres of water.
1 hour after 5 grs. quinine; cataract	=	1·6	„	„
1½ „ „ „	=	1·6	„	„
2 „ „ „	=	1·6	„	„
2½ „ „ „	=	2·1 to 3·1	„	„
After many days taking quinine „	=	6·2 to 3·1	„	„

The figures represent the number of grains of sulphate of quinine in 100 litres, 176 pints of water, required to give a fluorescence equal to that of the substances extracted.

Thus, then, the quinine goes everywhere; and wherever it goes it meets with the natural fluorescent substance like quinine which most probably is constantly forming and undergoing oxidation. The incoming quinine causes a temporary excess of quinine in the textures. Probably it causes a stoppage of the fresh formation of quinine from albumen; a temporary arrest of the changes going on; a transfer of action probably to the quinine introduced, so that with large doses deafness and great prostration and almost imperceptible pulse are produced in man, whilst in guinea-pigs death even is caused by the extreme prostration. In small doses, quinine, probably like alcohol, gives an immediate stimulus when the first chemical action takes place; but soon the quinine retards the chemical changes in the nitrogenous substances, just as alcohol, by its secondary action, retards the chemical changes in the hydro-carbons in the different textures.

Possibly the increased resistance to changes in the textures and in the blood produced by excessive doses of quinine or alcohol, is analogous to that state well known to medical men under the very indefinite and probably incorrect name of uremia.

From these experiments two hopeful prospects of possible discovery arise—1st, as to the explanation of the cause and cure of ague; 2nd, as to the treatment of diseases in parts of the body external to the blood vessels.

1. Assume that a substance like quinine exists, in health, in the textures, can its rapid destruction and removal through the action of marsh miasm give rise to ague? Does quinine cure ague by furnishing a substance which retards the changes which go on in the textures? and in the well-known property of arsenic to preserve organic substances have we also the explanation of its power in curing ague?

2. If the chemical circulation can carry alkaloids even into the non-vascular tissues, is it not reasonable to suppose that medicines pass through the blood and act on the textures? and is it not most probable that they take part in every chemical change that occurs outside the blood vessels, as well as in the blood itself? Still further, may we not expect that among the multitude of new substances which synthetical chemistry is now constantly forming, some medicines may be discovered which may not only have power to control the excessive chemical

changes of the textures in fevers and inflammations, but may be able to remove the products of insufficient chemical action even in those diseases which affect the non-vascular textures, as, for example, in cataract and in gout?

It remains that I should in a very few words tell you what was already known regarding this fluorescent substance, and on the rate of passage of alkaloids into and out of the body, before we begin our work.

In 1845, Professor Brücke stated that the lens absorbed the blue rays of light to a very great extent, and that the cornea and aqueous humour did so to a less extent. In 1855, Professor Helmholtz examined for fluorescence the retina of the eye of a man who had been dead for eighteen hours. The first experiment showed that it was very feebly fluorescent. The colour of the light dispersed through the retina he found greenish-white.

In 1858, M. Jules Regnauld, using sun light, found in man and the mammifera that the cornea fluoresced in a very slight degree. In the sheep, dog, cat, and rabbit the crystalline lens possessed in the highest degree fluorescent properties. In these animals, and also in many birds, the central part of the lens, preserved by dessication at a low temperature, retained this property. The central portion of the crystalline of many aquatic vertebrata and mollusca he found almost entirely without fluorescence. The vitreous humour possesses only a very feeble fluorescence, due to the hyaline membrane. The retina possessed a certain fluorescence which was not at all comparable in intensity to that of the crystalline lens.

In 1859, I. Setschenow, of Moscow, a pupil of Helmholtz, at his request, experimented on the eyes of men and rabbits. The fresh retina showed the same phenomenon as the dead human retina. It diffused a greenish-white light, which, examined by a prism, gives a spectrum in which the red is wanting. The vitreous humour in a thin glass vessel showed only traces of fluorescence. The lens, on the contrary, fluoresced very strongly, the colour of the dispersed light being white-blue, exactly like quinine, only the quinine was a little stronger. Examined by a prism, the dispersed light gave a spectrum in which the red was wanting, and in which the blue-tone predominated. The fluorescence begins as in quinine solutions between G and H, and is strongest at the outer edge of the violet rays, and extends into the ultra violet to the same distance in the case of the lens as in the case of the quinine solution.

When the cornea was cut out, it fluoresced much feebler than the lens; the aqueous humour did not fluoresce at all.

The appearances in the three last media, he says, can be shown with the greatest ease, even in the eye of the living man. When the eye is brought into the focus of the ultra violet rays immediately the cornea and the lens begin to glimmer with a white blue light. The cornea in the living eye is much more fluorescent than when dissected out, probably from the loss of transparency, consequent on contraction of the texture, and from evaporation.

Professor Donders has carefully investigated the time in which atropine and Calabar bean act on the iris in man.

A solution of atropine dropped on the cornea in 15 minutes begins to act, and attains its maximum in from 20 to 25 minutes. In 42 hours the pupil is rather smaller, and even after 13 days the pupil was not quite its natural size.

The fluid extracted from the aqueous humour, injected into another eye, caused dilatation of the pupil.

A solution of Calabar bean began to act in from 5 to 10 minutes; attained its maximum in from 30 to 40 minutes. At the end of three hours it began to diminish, and disappeared entirely in from two to four days.

[H. B. J.]

GENERAL MONTHLY MEETING,

Monday, April 2, 1866.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

John Curwen Christian Boyd, Esq.
Charles Browne Cornish-Browne, Esq.
Walter Thomas Fawcett, Esq.
Mrs. Bridget Margaret Sortain.
Calvert Toulmin, Esq.

were *elected* Members of the Royal Institution.

The Special Thanks of the Members were returned to EDWARD OWEN TUDOR, Esq., for his Contribution of 21*l.* to "the Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

The PRESENTS received since the last Meeting were laid on the table, and the thanks of the Members returned for the same, viz.:—

British Museum Trustees—Catalogue of Seals and Whales. 8vo. 1866.
Astronomical Society, Royal—Monthly Notices, 1865-6. No. 4. 8vo.
Basel Natural History Society—Verhandlungen, IV. Theil IV. Heft 2. 8vo. 1866.
British Architects' Institute, Royal—Sessional Papers, 1865-6. Part II. No. 4. 4to.
Chemical Society—Journal for Feb. 1866. 8vo.
Dublin Society, Royal—Journal, No. XXXIV. 8vo. 1865.

Editors—Artizan for March, 1866. 4to.
Athenæum for March, 1866. 4to.
British Journal of Photography for March, 1866. 4to.
Chemical News for March, 1866. 4to.
Engineer for March, 1866. fol.
Horological Journal for March, 1866. 8vo.
Journal of Gas-Lighting for March, 1866. 4to.
Mechanics' Magazine for March, 1866. 8vo.
Pharmaceutical Journal for March, 1866.
Practical Mechanics' Journal for March, 1866. 4to.
Geological Society—Quarterly Journal, No. 85. 8vo. 1866.
Geological Survey (through Sir R. I. Murchison, Bart.)—Memoirs, 8 Parts. 8vo.
British Organic Remains. Decade 10, 11, and Monograph 2. 4to and 8vo.
Mineral Statistics. 1859, 1862, and 1864. 8vo.
Seven Catalogues. 8vo.
Horticultural Society, Royal—Proceedings, 1866. No. 3. 8vo.
Journal, Vol. I. No. 2. 1866. 8vo.
Literary and Philosophical Society of Liverpool—Proceedings, No. XIX. Fifty-Fourth Session. 1864–5. 8vo.
Mechanical Engineers' Institution, Birmingham—Proceedings, Aug. 1865. Part 2. 8vo.
Photographic Society—Journal, No. 167. 8vo. 1866.
Pritchard, Rev. C. M.A. F.R.S. (the Author)—Eloges of Sir W. R. Hamilton and J. F. Encke. (From Monthly Notices. R. Astron. Soc. 1865-6.)
United Service Institution, Royal—Journal, No. XXXVII. 8vo. 1865.

Royal Institution of Great Britain.

1866.

WEEKLY EVENING MEETING,

Friday, April 13, 1866.

Sir HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

EMIL DU BOIS-REYMOND,
Professor of Physiology in the University of Berlin.

On the Time required for the Transmission of Volition and Sensation through the Nerves.

Introduction.—The speaker first pointed out a certain similarity of action between the nerves and telegraph-wires. Just as little as telegraph-wires, do the nerves betray by any external symptom that any or what news is speeding along them; and, like those wires, in order to be fit for service, they must be entire. But, unlike those wires, they do not, once cut, recover their conducting power when their ends are caused to meet again; in fact, every injury by which the organic structure of the nerve is impaired, such as bruising it between the blades of a forceps or by a ligature, or burning it, or corroding it by some chemical substance, will stop the transmission of either the influence of the will upon its central, or of the impressions of external objects upon its peripheric end.

This was illustrated by placing the sciatic nerve of a frog, still attached to the gastrocnemius muscle, on three electrodes, A, B, C—A being the remotest from, and C the nearest to, the muscle. A being connected with one end of a self-acting induction apparatus, and either B or C with the other end, a strong tetanus of the muscle ensued, and was rendered visible by the raising of a little mica flag;[*] but after a ligature had been tightened around the nerve between B and C, which was simply done by pressing down a lever,[†] the tetanus was observed to arise only on making the connection with C, because only then a portion of the nerve between the ligature and the muscle was stimulated, whereas, on making the connection with B, the ligature intercepted the effect produced by the stimulation of the portion AB.

---

[*] See the description and drawing of the apparatus in 'Beschreibung einiger Vorrichtungen und Versuchsweisen zu elektrophysiologischen Zwecken.' Von E. du Bois-Reymond. Abhandlungen der K. Akademie der Wissenschaften zu Berlin, 1862, S. 141 ff.

[†] The apparatus used is described and figured in 'Untersuchungen über thierische Elektricität.' Von E. du Bois-Reymond. Bd. ii. Abth. i. Berlin, 1849, S. 341; Taf. iii. Fig. 109, 110.

These facts, the speaker said, are calculated to impress us with a notion of something moving along the nerves in the act of volition and in that of sensation, which, to preclude any hypothetical view regarding its nature, we will term the *nervous agent*. As this agent for its conveyance requires an uninjured state of the nerve, being checked by so gross an obstacle as a cut or a ligature, it must necessarily be something material, not, however, the electricity such as it moves along a telegraph-wire, for this would readily overleap those impediments. But, whatever the nervous agent may be, it obviously must proceed in the nerves with a certain definite velocity. In other words, however great this velocity may be, a certain definite time will be required for the messages of the brain to reach the muscles and for those of the senses to reach the brain.

In common life, it is true, we never notice any phenomenon indicative of such a delay in the transmission of despatches in our nerves. Certainly our limbs do not instantaneously carry out the orders of our will; but this is rather owing to the circumstance of time being required for motion. On the other hand, we fancy we see the light, we hear the sound, we feel the prick on the toes as well as on the cheek at the very instant the corresponding organs of the senses have been affected. But a little reflection shows that this is altogether a delusion; in fact, if we only had one sense, an indefinite time might elapse between its organ being affected and the sensation taking place in the brain, without our perceiving it; we simply should always be so much behind the real time, just as we are when listening to distant music, or when looking at the stars. The same thing would also happen if we had two senses, both equally slow in working. We should only perceive that something was wrong, if the two senses had a different rate of working, and if the difference of time resulting therefrom for the perception of messages conveyed by the two senses were large enough to become apparent, as is the case when we see the flash of the gun before hearing its report. Now we cannot well distinguish intervals of time smaller than one-tenth of a second at the most; so that within that limit any irregularity in the working of our organs of sense may occur, from any cause whatever, hence from a delay of the messages in the nerves, without our becoming aware of it.

The problem thus suggests itself, to ascertain whether any perceptible time is required for the transmission of volition and sensation through the nerves, and if so, what is the rate of propagation of the nervous agent.

Historical Remarks.—This problem is by no means a new one; for a hundred and fifty years it has engaged the attention of physiologists, and many an adventurous hypothesis has been broached in order to approach to at least a pretence of a solution.

One of the early Iatro-mathematicians preposterously conceived that the velocity of the nervous agent ought to bear the same proportion to that of the blood in the aorta as the width of the aorta to that of the nerve-tubes, and he thus inferred the velocity of the former to be one hundred and twenty millions of miles in one second, rather more than six hundred times the velocity of light.*

Haller himself tried, in reading the Æneid aloud, how many letters he could pronounce in one minute. Finding that they were fifteen hundred, among which the R, according to him, requires for its formation ten successive contractions of the M. styloglossus, he states that in one minute a muscle may contract and relax fifteen thousand times, and as the relaxing lasts as long as the contracting, each contraction would have lasted only $\frac{1}{30000}$ of a minute, or $\frac{1}{500}$ of a second. Hence Haller argues that the nervous agent requires $\frac{1}{500}$ of a second for travelling from the brain to the M. styloglossus, say a distance of about four inches, which makes about 160 feet in one second. Now this result is not a little remarkable. In Haller's reasoning every single step is erroneous, and the whole rests on a perfectly absurd basis. Nevertheless, the result to which Haller has thus been led wonderfully coincides with that which has recently been arrived at by the methods which it is the object of this lecture to explain; so that in this case the Æneid really has proved a book of oracles.†

John Müller, of Berlin, hardly seventeen years ago, used in his lectures to dwell upon the apparent impossibility of ever solving the problem under consideration, on account of the enormous rate of propagation, comparable to that of light and electricity, which he ascribed to the nervous agent, while the small compass of the animal body did not offer sufficient range for its measurement.‡

These historical details, perhaps, will not be deemed superfluous, in as much as they are calculated to bring out more fully the beauty and the high scientific value of the following researches.

Description of M. Pouillet's Chronoscope.—More than twenty years ago, M. Pouillet suggested a very ingenious plan for measuring the velocity of projectiles. If an electric current flows constantly through the coil of a galvanometer, the needle is deflected to an amount which depends upon the intensity of the current, and upon the sensitiveness of the galvanometer. But if the current be sent through the coil only for a time so short that it vanishes when compared to the duration of one oscillation of the needle, things happen differently. The needle then receives as it were a single impulse, yielding to which it slowly recedes, till its velocity has been annihilated by the magnetic force of the earth, which draws it back to zero. And the initial velocity imparted to the needle by the current, provided this be of constant intensity, will be proportional to its duration, so that from the velocity, which can be calculated from the deflection of the needle, the duration of the current may be inferred. The galvanometer is thus transformed into a *chronoscope*, which can be used for measuring the duration of rapidly transient processes, whenever there is a possibility of making the beginning and the end of the process coincide with the beginning and the end of the *chronoscopic current*,—for so we will style the current, which, by its action on the galvanometer, becomes an indicator of time. And similarly we will style *chronoscopic circuit*, the circuit of the chronoscopic current.

---

* Haller, 'Elementa Physiologiæ Corporis humani.' Tom. iv. Lausannæ, 1762. 4°. P. 372.

† Ibidem, pp. 373, 483.

‡ 'Handbuch der Physiologie des Menschen, u. s. w.' Bd. i. 4 Aufl. Coblenz, 1844. S. 581.

If, *e. g.*, the velocity of a bullet, within the very barrel of a gun, were to be measured, the chronoscopic circuit, in addition to the battery and the galvanometer, should comprise a wire stretched out just before the muzzle of the gun, the cock, which in some way or other should be insulated from the gun, and lastly the gun itself. Then at the moment when the cock strikes the percussion-cap, the circuit is made and remains so till the bullet tears the wire ; and so the current will only have lasted during the time required for the explosion of the percussion-cap, for that of the gunpowder in the gun, and for the moving of the bullet along the barrel. This time has been found to be from $\frac{1}{150}$ to $\frac{1}{140}$ of a second. By repeating the same experiment with the wire or a net of wires at any greater distance from the muzzle, and by taking the difference of the times required in both cases, the time elapsed during the flight of the bullet through the space comprised between the two positions of the wire can be ascertained.*

Application of this Method to our Problem by Professor Helmholtz.—The same method was, a few years later (1850), successfully applied by Professor Helmholtz to the solution of our problem.

Suppose that the chronoscopic current, when its circuit is made, causes the muscle to contract by stimulating a motor nerve at a point A. It will be easy to arrange things so as to cause the muscle by its contraction to break the circuit. The current will then have lasted the time necessary for the transmission of the nervous agent from the point A of the nerve to the muscle, and, moreover, that necessary for the muscular contraction to break the circuit. But by repeating the experiment, with the sole difference that the chronoscopic current is made to act upon a point B of the nerve farther from the muscle than A, and by taking the difference of the times required in both cases, the time which elapses while the nervous agent is travelling from point B to point A will be found.

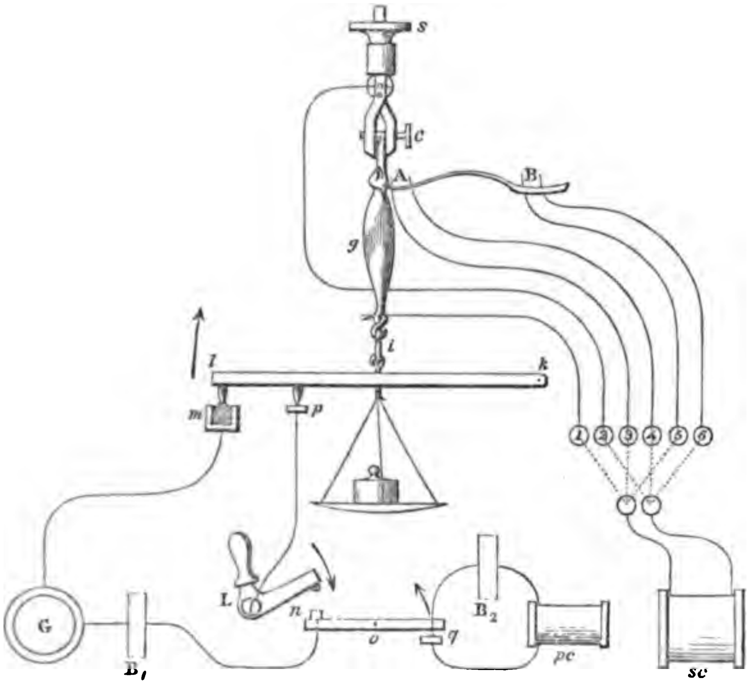
Fig. 1 shows the experiment, not exactly as made by Professor

---

* 'Comptes Rendus,' &c. 1844, t. xix. p. 1384.

Helmholtz, but with some slight modifications, that the speaker has introduced for the sake of convenience. *g* is the gastrocnemius muscle of a frog, fastened by the thigh-bone in the clamp *c*, which can be raised or lowered by the screw *s*. Through the *tendo-Achillis* a hook is thrust, and to this, by an insulating piece *i*, a brass lever *lk* is attached, turning on the axis *k*, and, near its end *l*, supported by a platinum point resting on a platinum plate *p*. Just underneath the muscle, a scale-pan is suspended from the lever, on which any suitable weight may be placed. At the end *l* of the lever an amalgamated copper point dips into a mercury cup *m*. G is the galvanometer-coil; and it is hardly necessary to mention that the readings are made with mirror, telescope, and scale. B_1 is the battery belonging to the chronoscopic circuit. This circuit is formed by B_1, G, *m*, *p*, L, and the place of contact *n*, where for the present it is interrupted. For several reasons, which it would take too long here to explain, the chronoscopic current cannot be employed for directly stimulating the nerve by its beginning, and this has to be done indirectly, in the following way :

Fig. 1.



n o q is an insulating lever turning on the axis *o*, and bearing at *n* a platinum plate connected with B_1. This plate corresponds to a platinum point at the end of the brass lever L, which in its turn is connected with *p*, so that by pressing down L, the chronoscopic circuit is made. But by pressing down the extremity *n* of the lever *n o q*, its extremity *q* is simultaneously raised, and thus another circuit is broken. This circuit comprises a battery B_2, and the primary coil *pc* of an induction apparatus, from whose secondary coil *sc* wires extend to the part of the nerve which is to be stimulated, or to the muscle. No perceptible time elapses between the breaking of the primary circuit and the generation of the induced current, and the duration of the latter does not exceed a few ten-thousandths of a second. Hence the stimulation of the nerve can be assumed to happen at the very instant the chronoscopic circuit is made.

By means of the screw *s*, it is easy to make the muscle support the lever *l k* so that the platinum point just rests on the plate *p*. This is done by lowering the screw, till on percussing the lever above the platinum point no clattering is heard. If now the tension of the muscle be ever so little increased, the lever will be lifted, and the chronoscopic circuit broken at *p*.

After the contraction is over, as the lever sinks back into its original position, the chronoscopic circuit would be made again, and the experiment spoilt in consequence of the new and overpowering action exercised on the needle, unless some measure were taken to prevent it. This very serious difficulty has been met by Professor Helmholtz with singular felicity. The mercury cup into which the amalgamated copper point dips is lowered before the experiment, till by capillary attraction the mercury is drawn up in a cone connected with the point by a thread. The slightest upward motion of the point then will cause the mercury thread to break, after which the liquid metal speedily reassumes its spheroidal surface. So that when the amalgamated point comes down again, it cannot reach the mercury, and the chronoscopic circuit remains open.

In order to obtain a clear insight into the conditions of the experiment, it should first be made by stimulating, not the nerve, but the muscle itself. For this purpose, the ends of the secondary coil should be united with the wires 1 and 2 in the diagram. As, on doing so, all the parts of the muscle are acted upon simultaneously at the very instant the chronoscopic circuit is made, no delay in the nerves can occur; nevertheless, a deflection of the needle is thus obtained, which shows that after the stimulation there is an interval of time of about ·01 of a second, during which the tension of the muscle still remains unaltered. This interval has been styled by Professor Helmholtz the *stage of latent stimulation.*

If, after having made the muscle support the lever so that it just rests on the plate *p*, a weight be placed upon the scale-pan, the deflection obtained on stimulating the muscle as before, is increased, and, up to a certain limit, the more so the heavier the weight. It thus appears that after the stage of latent stimulation is over, the muscle does not at once acquire its whole energy, but that its tension (at equal length) gradually increases, and reaches its maximum after about ·05 of a second.

This result (which the speaker illustrated by two experiments, one without, and the other with an additional charge on the scale-pan) is in itself of considerable interest, as it shows that the difference which, up to the time of Professor Helmholtz's researches, had been admitted between the mode of contracting of the striped and of the unstriped muscles is only one of gradation. Of the latter class of muscles, in contradistinction to the first class, it was said that their contraction did not immediately follow stimulation, and that their energy rose, and subsided again, gradually. But it is now obvious that all this holds equally with the striped muscles, only that the whole process here lasts but a few hundredths of a second, whereas with the unstriped muscles every stage of the contraction may take up as many seconds, so as to be easily perceptible without artificial means.

The values obtained in repeated trials for the duration of the latent stimulation do not accord very well; but those which represent the time required by the muscle to raise an additional weight remain almost identical as long as the muscle does not become exhausted, provided the stimulation be capable of producing the maximum of contraction which can be called forth by instantaneous stimulation. This also happens when, instead of stimulating the muscle itself, the induced current, in successive trials, is made to act with sufficient energy upon always the same part of the nerve, only in this case the time of latent stimulation is found to be a little longer than in the case of the muscle itself being stimulated. But on making the current pass alternately through the part A of the nerve nearer to the muscle, by means of the wires 3 and 4 in the diagram, and through the part B farther from the muscle, by means of the wires 5 and 6, two sets of observations are obtained, the corresponding figures of which differ from each other by a small but constant quantity, independent, moreover, of the additional charge placed upon the scale-pan. This difference obviously indicates the time required by the nervous agent for travelling from B to A, and the distance between A and B being known, the rate of propagation of the stimulation or the velocity of the nervous agent can easily be calculated.

This velocity, in Professor Helmholtz's experiments, has been found to be 26·4 mètres (86·6 feet) in one second.* The reason why on stimulating the nerve the time of latent stimulation appears a little longer than on stimulating the muscle itself, is now also evident. It is owing to the time which elapses during the passage of the nervous agent from the stimulated part of the nerve-tubes to their termination in the muscle.

---

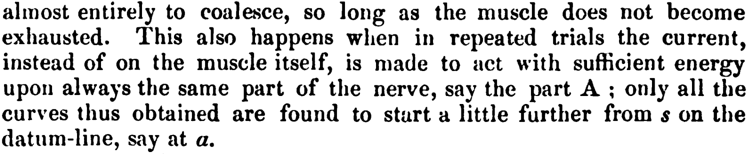
* Joh. Müller's 'Archiv für Anatomie, Physiologie und wissenschaftliche Medicin.' Berlin, 1850. S. 276.

Professor Helmholtz's Experiments with the Myographion.—Soon after Professor Helmholtz had thus, for the first time, succeeded in determining the velocity of the nervous agent, he devised another method for obtaining the same result in a manner more simple and more adapted to a variety of purposes.

As before, the gastrocnemius muscle is caused to lift a lever by its contraction, but this time with the view of making the muscle itself register the beginning, and the successive stages, of the contraction; wherefore the apparatus employed is termed a *myographion*. To this end, opposite a steel point or style suspended from the lever is placed a rotating cylinder of glass, blackened over a lamp. The cylinder is moved by clockwork at an increasing rate, and, when it has acquired the proper speed, the centrifugal force developed releases a piece of mechanism which breaks the primary circuit of the induction apparatus connected with the muscle or nerve. In consequence of a very ingenious arrangement, which will hereafter be explained, this always happens when the cylinder is in exactly the same position to the style; so that always the same point of the datum-line traced by the style during the quiescent state of the muscle corresponds to the instant of stimulation.

The contracting muscle thus traces a curve on the cylinder, like those in Fig. 2. The point *s* of the datum-line marks the instant of stimulation. The curve does not start from this point, but a little later, from *m*, the distance *sm* corresponding to the stage of latent stimulation, if we suppose the muscle to have been acted upon directly by the current. The muscle then, slowly and gradually, begins to act, in due time reaches a climax of energy, and then again gradually relaxes. The results obtained by M. Pouillet's method regarding the successive stages of contraction are thus confirmed by the graphic method. The curve traced by the contracting muscle of course becomes the more stretched the quicker the cylinder rotates, but, at an equal rate of rotation, the curves traced successively by the same muscle stimulated by a current capable of giving rise to the maximum of contraction, coincide so as almost entirely to coalesce, so long as the muscle does not become exhausted. This also happens when in repeated trials the current, instead of on the muscle itself, is made to act with sufficient energy upon always the same part of the nerve, say the part A; only all the curves thus obtained are found to start a little further from *s* on the datum-line, say at *a*.

FIG. 2.



But, on stimulating the nerve alternately at a place A nearer to, and B farther from, the muscle, the curves obtained no longer coincide. They separate, and the curves traced on stimulating B will again be found to lie farther off on the datum-line, starting at *b* instead of at *a*, and keeping everywhere the same horizontal distance *a b* from the curve traced when A is stimulated.

This horizontal distance of the two curves, or sets of curves, evidently corresponds to the time the nervous agent has spent in travelling along the nerve from B to A. It is, in fact, the displacement of the surface of the cylinder which, according to its angular velocity, has occurred during the same time. Determining this angular velocity by means of an indicator, the velocity of the nervous agent was found by Professor Helmholtz to be 27·25 mètres (89·4 feet) in one second, which agrees very well with the figure formerly obtained by M. Pouillet's method.[*] It is hardly necessary to mention that the difference *s a—s m* corresponds to the time spent by the nervous agent in travelling from A to the termination of the nerve-tubes in the muscle.

Different kinds of Myographion proposed; description of the Apparatus used by the speaker on the present occasion.—The myographion, as it was originally designed by Professor Helmholtz, is a rather complicated and expensive apparatus. Various modifications have been proposed in order to simplify it. For the clockwork moving the cylinder, Thiry has substituted a reaction-engine moved by air, like that in M. Foucault's apparatus for comparing the velocity of light in air and in water. The rotation of the cylinder in this myographion is uniform, and its rate is ascertained by the pitch of a siren connected with it.[†] Harless and Professor Fick altogether abandoned the rotating scheme, which, in fact, involves great and, perhaps, unnecessary difficulties, and for the rotating cylinder substituted a glass plate moving in its own plane. Harless allowed the plate to drop in an apparatus constructed upon the principle of Atwood's machine, and thus obtained an uniform velocity, which could easily be determined theoretically.[‡] Professor Fick attached the plate to a heavy pendulum, and although the velocity thus was no longer uniform, yet the law of its variation was known.[§]

The speaker himself had formerly devoted much attention to the improvement of the rotating myographion, and had suggested some alterations of it, which, executed by that most skilful instrument-maker, M. Sauerwald, of Berlin, answer remarkably well, and have done good service in some very important researches, hereafter to be mentioned.[‖] For the present occasion, however, he contrived a new myographion which in simplicity far exceeds every previous design, and which may be styled the *spring-myographion.* As in Harless's and in Professor Fick's myographion, in the spring-myographion the cylinder is replaced by a glass plate moving in its own plane. But instead of being impelled by gravity, the plate, on pulling a trigger, is, as it were, shot by a spiral spring along two horizontal steel wires which act as supports and guides. The curve is traced on the plate, after this has reached its greatest velocity, *i. e.* after the spring has passed through its position of equilibrium. On account of the friction, however, the velocity of the plate cannot be taken as uniform, nor can the law of its variation and its amount at any given place theoretically be ascertained with any degree of precision. But, if required, this could easily be done experimentally, by recurring to Dr. Thomas Young's original plan*—*viz.* by causing a tuning-fork to record its vibrations upon the plate, together with the curve traced by the contraction of the muscle. On the present occasion this would be useless, as it is only intended to show that there is a larger interval between the instant of stimulation and the beginning of contraction, if a part of the nerve farther from, than if a part of it nearer to, the muscle be acted upon. For this purpose it is only requisite that the motion of the plate should always follow the same law and attain the same velocity, and that the point of the datum-line, corresponding to the instant of stimulation, should always be the same.

---

[*] Joh. Müller's 'Archiv, u. s. w., 1852.' S. 199.

[†] Henle und Pfeuffer, 'Zeitschrift für rationelle Medicin,' 3. R. Bd. xxi. 1864, S. 300.

[‡] 'Abhandlungen der K. bayer. Akademie der Wiss.' II. Cl. Bd. ix. Abth. ii. München, 1862. S. 361.

[§] 'Vierteljahrschrift der Naturforschenden Gesellschaft in Zürich,' 1862, S. 307.

[‖] A. v. Bezold, 'Untersuchungen über die elektrische Erregung der Nerven und Muskeln.' Leipzig, 1861. S. 85.

In the spring-myographion the latter condition is fulfilled in the same manner as in Professor Helmholtz's, and every other myographion. The frame carrying the plate has a projecting piece or tooth, which, just when the frame has reached its highest speed, strikes a lever, and thus breaks the primary circuit of the induction apparatus. This, of course, always happens in exactly the same position of the plate, whatever may be its velocity; so that in order to find the point of the datum-line corresponding to the instant of stimulation, it is only necessary to move the plate with the hand along its guides so slowly that the contraction of the muscle, instead of a curve, traces a vertical line ($s\,s^1$ in Fig. 2) corresponding to the two limbs of the curve, the ascending and the descending one, which have coalesced.

A very essential precaution in these, as well as in all experiments on nerves and muscles, is that these textures, especially the nerves, should be carefully preserved from becoming dry. This can be done by covering the part of the apparatus containing them with a shade the inner walls of which are lined with moist bibulous paper; or, as was the case on the present occasion, by enclosing the nerve in a tube of vulcanite, in which it rests on two pairs of platinum electrodes, one as near to, the other as far from, the muscle as possible.

---

* 'A Course of Lectures on Natural Philosophy and the Mechanical Arts.' London, 1807. Vol. i. p. 190.

This tube of vulcanite is also provided with another contrivance, which will be more fully mentioned presently.

The speaker now proceeded to show a complete experiment with the spring-myographion. After two curves had been traced, one by stimulating the nerve near to, the other by stimulating it far from, the muscle, the magnified image of the curves was exhibited to the audience by means of the electric light.

Conditions upon which the rate of Propagation of the Nervous Agent has been hitherto found to depend.—1. The figures given above (see pages 579 and 582) for the rate of propagation of the nervous agent were obtained at a temperature of from 11° to 21° C. At a lower temperature, Professor Helmholtz found the velocity was greatly diminished.[*] This can easily be shown by means of the tube of vulcanite belonging to the speaker's new myographion. The nerve, inside the tube and between the two pairs of electrodes, rests on a varnished copper-plate, which forms part of a small vessel, lodged in the wall of the vulcanite tube. Through this vessel water of any temperature may be passed. By thus cooling the nerve, a wider interval is obtained between the two curves; in fact, this artifice was put into practice in the above-mentioned experiment to make the result more striking. Plates were also exhibited with curves traced on them at a higher and a still lower temperature, thus showing that the horizontal distance of the two curves is in a measure proportional to the lowering of the temperature.

2. Dr. H. Munk, by delicate researches made in the speaker's laboratory, has succeeded in demonstrating that the velocity of the nervous agent is not the same in different parts of the same nerve. According to him, this velocity in the motor nerves increases as the nerve approaches the muscle.[†]

3. Professor v. Bezold, also in the speaker's laboratory, has undertaken to answer the question whether and how the velocity of the nervous agent may be altered by the *electrotonic state* of the nerve—as sixteen years ago the speaker ventured to term the remarkable condition into which he found the whole nerve thrown when any part of it is pervaded by an electric current; a condition making itself manifest by a most striking change in the electromotive action of the nerve,[‡] and, as afterwards demonstrated chiefly by Professor Pflüger, also by a change in the excitability of its different points.[§] These changes, which only last as long as the current itself, are found to be the more considerable, the nearer to the electrodes the nerves are examined. In addition to these facts, Professor v.

---

[*] Joh. Müller's 'Archiv, u. s. w. 1850,' S. 358.

[†] Reichert's und du Bois-Reymond's 'Archiv für Anatomie, u. s. w. 1860,' S. 798.

[‡] 'Untersuchungen über thierische Elektricität,' Bd. ii., Abth. i. Berlin. 1849. S. 289. 'On Animal Electricity,' &c., by H. Bence Jones. London, 1852. P. 174.

[§] 'Untersuchungen über die Physiologie des Electrotonus.' Berlin, 1859.

Bezold found the velocity of the nervous agent to be diminished in the electrotonic state, and that also the more, the nearer to the electrodes the nerves were examined. These researches were made with the speaker's improved rotating myographion, alluded to above. (See p. 582.)*

Rate of Transmission of Sensation in the Nerves and the Spinal Cord of Man.—All the preceding experiments were made upon the motor fibres in the sciatic nerve of the frog. Similar results, however, have been arrived at with regard to the nerves of sensation in the living body of man, in the following way.

An induced current is made to impinge alternately upon two different places on the skin, so as to cause just a slight sensation of pain. The two places should be such as are supplied, like the big toe and the inguinal region, for instance, with sensory fibres emanating from neighbouring roots, but of very unequal length. The person experimented on is desired, as soon as he becomes aware of the shock, or ***sensation-signal***, as it may be termed, to answer it by another signal, the ***volition-signal***, which generally consists in making or breaking a circuit at the instant when the sensation-signal is given ; and means are provided for measuring the time, that we shall designate by T, which elapses between the two signals. The time T comprises, firstly, the time required for the transmission of sensation to the brain—for its perception there—for volition—for the transmission of volition to the muscles—for muscular contraction ; secondly, T comprises the time lost in the purely mechanical and physical process of signaling. This last time, of course, depends upon the experimental method employed, and by suitable arrangement may even be reduced to nothing. Now, should the value of T, when the more distant place on the skin is stimulated, always, and by nearly the same amount, exceed its value when the nearer place is stimulated, then, as everything else in both experiments remains the same, the difference of time must obviously depend upon the unequal distance which in both cases the nervous agent has to travel from the place stimulated to the brain.

This scheme also, in the main, was suggested by Professor Helmholtz, as early as 1850 ;† the first correct results, however, were thus arrived at eleven years later by Dr. Hirsch, the able astronomer of Neuchâtel in Switzerland, by means of Hipp's chronoscope, which he so regulated as to obtain the first part of the time T, *i. e.* that merely occupied by physiological processes, entirely free from the second.‡ For that physiological part of the time T, with reference to the part it plays in modern astronomical observation, he proposed the name of *physiological time.* The subject has since been taken up, and as regards physiology more fully treated by Dr. Schelske, of Berlin, whose experiments were made at the Utrecht Observatory, by means of the chronograph now in use among astronomers for registering their observations.

---

* A. v. Bezold, 'Untersuchungen über die elektrische Erregung der Nerven und Muskeln.' Leipzig, 1861.

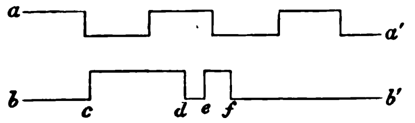
† 'Königsberger Naturwissenschaftliche Unterhaltungen.' Bd. ii. Hft. ii. 1851. S. 169.

‡ Moleschott's 'Untersuchungen zur Naturlehre des Menschen und der Thiere,' Bd. ix. S. 183.

In this chronograph, as constructed by Krille, of Hamburg, there is again a rotating cylinder, on whose blackened surface two points or styles, *a* and *b*, mark a spiral track. Each of them is fixed to the keeper of an electro-magnet, and, when the keeper is attracted, deviates a little from its path, so as to trace a broken line. The circuit of the magnet A is alternately made and broken by the pendulum of a clock, in accordance wherewith the style *a* traces a broken line like *aa'* in Fig. 3, every horizontal segment of which corresponds to one second. The circuit of the magnet B contains the primary coil of the induction apparatus, whose secondary coil is connected with the skin of the person experimented on. Two *keys*, moreover, form part of this circuit: a *lever-key*, which, when pressed down, keeps the circuit closed by establishing a bridge between two points of it; and a *spring-key*, which the person holds in his hand, ready, by it, to make the circuit again after it has been broken by the lever-key.

All the rest is very simple, and easily understood when looking at the broken line *bb'* in Fig. 3, which is the record of an experiment as written down by the style *b*. At *c*, the lever-key has been pressed down in order to prepare the experiment. At *d*, the circuit of the magnet B, and of the primary coil of the induction apparatus, has been broken, and the induction current passed through the skin, all by again lifting the lever-key. At *e* the person, having perceived the shock, has made the circuit again by means of the spring-key, and at *f* has broken it once more, in order to render another experiment possible. So that the distance *de* here would correspond to the time we have designated by T, and would be found to be greater or smaller according to the distance the nervous agent had to travel from the stimulated place on the skin to the brain.

Fig. 3.



The velocity of the nervous agent in the nerves of common sensation, in the living body of man, has thus been found by Dr. Schelske to be 29·6 mètres (97·1 feet) in one second, which is only very little more than the result obtained for the motor nerves of the frog. (See pages 579 and 582.)*

---

* Reichert's und du Bois-Reymond's 'Archiv, u. s. w. 1864.' S. 151.

By similar experiments, Dr. Schelske has ascertained that the transmission of sensation through the spinal cord of man takes place at very nearly the same rate as in the nerves. This is the more remarkable, as in other respects the nerve-tubes undergo a material change on entering the spinal cord, where, according to Professor van Deen, of Groningen, and others, they are no longer capable of stimulation by electricity, chemical substances, mechanical injuries, &c.

Considerations suggested by the foregoing Results.—The following table affords an opportunity of comparing the velocity of the nervous agent, as it has been established by the foregoing researches, with that of several other agents, or bodies in motion, from which comparison some interesting conclusions may be drawn :—

VELOCITY OF	Mètres in one second.
Electricity in Mr. Wheatstone's experiment	464,000,000
Light	300,000,000
Sound in Iron	3,485
,, Water	1,435
,, Air	332
Shooting Star	64,380
Earth in Orbit round Sun	30,800
Earth's Surface at Equator	465
Cannon-ball	552*
Wind	1—20
Eagle's flight	35†
Locomotive	27
Greyhound, Racehorse	25
Nervous Agent	26—30
Hand throwing stone $24^{m}\cdot5$ high	21·9
Muscular contraction	0·8—1·2
Arterial wave	9·25
Blood in dog's carotid	0·2—0·3
,, capillaries	0·0006—0·0009
Particles moved by cilia	0·00007

A glance at this table shows that the velocity of the nervous agent, far from being enormously great, as most physiologists formerly supposed, is, on the contrary, wonderfully small. Not only is it beyond any comparison smaller than the velocity of electricity and light, and the so-called planetary velocities, but it is even small when compared to the velocity of sound in different media, or to the initial velocity of a cannon-ball.

In order better to realize how slowly sensation and volition are transmitted through the nerves, let us suppose that a large whale, which may be thirty mètres long (98½ feet), has its tail struck by a harpoon. It will then take about one whole second before the pain reaches the huge creature's brain ; and, neglecting even the time required for the processes in the brain, nearly another second will elapse before the order can be telegraphed to the muscles of the tail to capsize the boat.

---

* Rev. Samuel Haughton, in the 'Proceedings of the Royal Irish Academy, 1862,' vol. viii. p. 113.

† Simmler, 'Poggendorff's Annalen, u. s. w. 1864.' Bd. cxxi. S. 331.

Again, suppose the engine-driver on the locomotive of an express-train running a mile a minute, holds his arm extended towards the tender, and moves his fingers, then the nervous agent in the motor fibres of his arm will rest in space or nearly so, because its motion is destroyed by that of the train, just as a cannon-ball, fired at the equator due west, has its motion destroyed by that of the earth around its axis, and does not strike the wall or the ship's side, but is struck by them. And the same thing will happen with the nervous agent in the sensory fibres of the fireman's arm, if, standing on the tender, he should burn his hand at the locomotive.

But also in the racehorse and greyhound, when they are running at full speed, the nervous agent will nearly rest in space, and in the flying eagle it will even be carried in the opposite direction.

As in these cases the whole body of the animal is darted through space at a rate equal or even superior to that of the nervous agent, it will be less a matter of surprise that a man should be able to move his hand almost as quickly as that agent moves along his nerves. This can be made apparent by the height to which a heavy body, a stone, for instance, may be thrown. Throwing, in fact, is nothing else than imparting the greatest possible velocity to the hand, together with the projectile, and letting this fly when the tangent to the curve, wherein the hand necessarily moves, points in the proper direction. The initial velocity of the stone, then, can never exceed that of the hand, or the velocity of the hand, on throwing the stone vertically, must have been equal to that with which the falling stone passes through the horizontal plane from which it started. This reasoning leads to the result put down in the table, and it may safely be conjectured that the same figure also applies with tolerable accuracy to the motion of the fist when striking a blow.

The *arterial wave*, which in more superficial arteries is felt as pulse, travels only about three times more slowly than the nervous agent, according to Professor E. H. Weber's observations.*

By the *velocity of the muscular contraction*, we understand the rate at which the wave of contraction runs along the fibre, when one end of the muscle is stimulated. This rate has been ascertained by Professor Aeby, now of Berne, by experiments made on the muscles of frogs poisoned with Curare, in order to exclude the co-operation of the nerves, and by means of a myographion, on whose cylinder two styles marked their track. The lever bearing each style rested on the muscle with a sort of crutch, and when the wave of contraction passed under the crutch, it was raised by the thickening of the muscle. Two curves were thus obtained, whose horizontal distance was equal to the distance of the styles, *plus* the distance corresponding on the cylinder to the time spent by the wave of contraction in travelling from the first to the second crutch. The velocity of the contraction thus obtained, falls as much short of that anticipated by theory, as did that of the nervous agent; being, in fact, even in muscles fresh from the body of the frog, only about one yard in one second.[*]

---

* 'De pulsu, resorptione, auditu et tactu. Annotationes anatomicæ et physiologicæ,' &c. Lipsiæ, 1831. 4°, p. 2.

Time required for Reflex Action in the Spinal Cord.—The conduction of sensation in the spinal cord, according to Dr. Schelske's above-mentioned experiments, takes place at nearly, perhaps quite, the same rate as in the nerves; but a great delay is occasioned by the so-called reflex-action, when the sensation, impinging upon the spinal cord, starts an involuntary motion by the intervention of the ganglionic cells. By experiments performed on frogs poisoned with strychnia, Professor Helmholtz has found that the reflex contraction happens from $\frac{1}{30}$ to $\frac{1}{10}$ of a second later than the contraction directly produced by the same induced current; from which observation it may be concluded, that the reflex action in the spinal cord takes more than twelve times the time required for the transmission of the stimulation through the sensory and the motor nerves.[†] This is doubly interesting, because it was chiefly by the impossibility of catching with the eye the slightest lapse of time between the stimulation and the reflex contraction that John Müller had been induced to admit, as we have pointed out, so enormous a velocity for the nervous agent.[‡]

Time required for Sensation and Volition in the Brain.—More recently researches of this kind have been extended even to the time required for one of the simplest operations of the brain—*viz.* the act of sensation and subsequent volition. Dr. de Jaager, in Professor Donders's laboratory, in Utrecht, first repeated Dr. Schelske's experiment on the transmission of sensation in the human body; but with this modification, that the shock could at will be given either on the right or on the left side. In one set of experiments, the person had to answer the right side shock with a spring-key in his right hand, the left side shock with a similar key in his left hand; and he knew, beforehand, on which side he was going to be stimulated, and therefore would have to answer. In another set of experiments the side was not known beforehand, and the person, after having received the shock, had first to consider which side had been struck, and with which hand, accordingly, he had to act. Now the mean result in the first case was— . . . . $T_1 = \cdot 205$ sec.

in the second . . . $T_2 = \cdot 272$

and the difference $T_2 - T_1 = \cdot 067$

is obviously the time spent in the operation of the brain required in the second, and not required in the first case.

The physiological time necessary for answering a signal given to the eye has also been determined by Dr. Hirsch by means of Hipp's chronoscope, regulated so as to eliminate the error in time resulting from the working of the apparatus. The sensation-signal being an electric spark, ·204 of a second elapsed before the volition-signal could be given; but if, while watching the rapidly moving hand of the chronoscope, the observer proposed to stop it at a given position on the dial (by throwing it out of gear, which with this chronoscope is the mode of making a volition-signal), only ·077 of a second were required for doing so.

---

[*] Dr. Ch. Aeby, 'Untersuchungen über die Fortpflanzungsgeschwindigkeit der Reizung in der quergestreiften Muskelfaser.' Braunschweig, 1862.

[†] 'Monatsberichte der Berliner Akademie der Wissenschaften, 1854.' S. 332.

[‡] L. c. p. 583.

Dr. de Jaager repeated these experiments with his chronograph and with variously coloured light, and he found that with red as well as with white light, ·200 of a second on the average were required for answering the signal. This figure cannot be compared directly with Dr. Hirsch's figures, with the first of which it so closely agrees, because Dr. de Jaager's observations represent the time T, those of Dr. Hirsch the physiological time only. In these trials the colour of the light to appear was known to the person, and he simply had to answer the signal with the right or with the left hand, according to what had been agreed upon beforehand. In other experiments, however, the colour of the light was not known, and it was agreed that red light should be answered with the right, white light with the left hand. Here the time required for answering was found = ·355 sec., that is ·154 of a second longer than in the first case, the latter figure again representing the time spent in the operation of the brain.

The physiological time intervening between a signal received by the ear and answered by Hipp's chronoscope has been found by Dr. Hirsch to be ·149 sec. Dr. de Jaager, in company with Professor Donders, has had recourse to quite another method for determining the same time. He has applied to this purpose Mr. Scott's phonautograph, as constructed by M. König, of Paris. In this apparatus a membrane partakes of the vibrations of any sounding body placed opposite the mouth of a paraboloid cavity over whose bottom that membrane is stretched; and a point connected with the membrane traces curves, indicative of its vibrations, on a blackened cylinder, on which simultaneously a tuning-fork records the time. Two persons, A and B, separated by a screen, sit down before the phonautograph. A utters some sharp, explosive syllable, such as *ka*, *ke*, *ki*, or the like. B endeavours to repeat the syllable as quickly as possible. The instant at which both persons have begun to utter the sound is plainly discernible in the track of the style on the cylinder. Now, if the syllable to be repeated has been agreed upon before, the time required varies from ·180 sec. to ·250 sec., according to the person experimented upon, and to practice; but if the syllable be unknown, about ·088 sec. more are necessary for answering the signal.* It thus appears that "*quick as thought*," is, after all, not so very quick.

---

* 'De physiologische Tijd bij psychische Processen, Academisch Proefschrift,' &c. Utrecht, 1 Julij, 1865.

Concluding Remarks.—The preceding results are not entirely without a practical bearing. In medicine, it is true, they have not yet been applied, although, perhaps, in cases of paralysis, the velocity of the nervous agent will be found diminished, and diagnostic signs, more or less important, might be derived therefrom. But as, strange to say, the warlike art of gunnery first supplied physiology with the means of measuring the velocity of the nervous agent, so again it is a science apparently far remote from this field of inquiry, astronomy, which is the first to benefit by the progress achieved in it. Astronomical observations, as regards the exact determination of time, have hitherto attained only a limited perfection. Till very recently, indeed, though the observations of the same astronomer might agree ever so closely, still, between the observations of several, even first-rate astronomers, discrepancies occurred of one second and more, resulting from the different estimate formed by the observers of the time between the passage of the star at the cross-wire and the next beat of the clock. This uncertainty as to the real time of an astronomical event has been greatly diminished by the introduction into observatories of the electric chronograph. It still subsists, however, and the only way of removing it as completely as possible seems to be that adopted by Dr. Hirsch, *viz.* to ascertain by appropriate experiments the time required for registering the passage at the cross-wire of an artificial star moving at a rate similar to that of the real stars, and thus, for the knowledge of the *personal equation* of two observers, to substitute that of their *personal corrections*, the difference of which corresponds to their personal equation.*

As to the theory of the nervous agent, now that we know that this agent moves more than ten times less quickly than sound in air, every attempt to identify it with the electric current as it circulates in a telegraph-wire must appear hopeless, even if a circuit, such as would be necessary for the supposed nerve current to circulate in, were anatomically demonstrated. Thus to the other arguments against this view of the nervous agent—that the resistance of the nerve-tubes would be far too great for any battery to send an available current through them—that the physiological insulation of the nerve-tubes from each other would be impossible to explain—that the effect of ligature or of cutting the nerve and causing its ends to meet again, would be equally obscure—to these arguments, unanswerable as they are in themselves, the researches sketched in this lecture have added corroborative evidence of the highest order. What we have termed the nervous agent, if we look upon its very small velocity, in all probability is some internal motion, perhaps even some chemical change, of the substance itself contained in the nerve-tubes, spreading along the tubes, according to the speaker's experiments, both ways from any point where the equilibrium has been disturbed; being capable of an almost infinite number of variations or gradations, and of so peculiar a character as to require the unimpaired condition of the nervous structure. It would be out of place on the present occasion to venture upon any more definite statement regarding the nature of the nervous agent, although the progress recently made in this line, chiefly by the modern school of German physiologists, already affords the means of doing so, and of discussing the merits and defects of several solutions proposed. It may not, however, be inappropriate to remark, that although the electric theory of the nervous agent, in the sense just alluded to, cannot any longer be thought of (as little, indeed, as with any degree of probability it ever could), yet it would be rash, as the matter stands, entirely to dismiss the notion of electricity being concerned, and even playing a prominent part, in the internal mechanism of the nerves. The electric currents discovered in the nerves by the speaker four-and-twenty years ago; the remarkable changes which these currents undergo whenever the nervous agent is called into action; the wonderful phenomena of electric fish; those of the muscles and glands; finally, the extreme sensitiveness of the nerves for electricity however applied, and the beautiful and peculiar laws which govern their reaction thereupon, all these are facts which certainly ought not to be disregarded as long as the close connection which they seem to indicate between the two agents has not otherwise proved a fallacy. Nor is it by any means impossible to frame an electrical hypothesis of the nervous agent such as would embrace that newly-discovered feature of it, which has formed the subject of this lecture—its comparative sluggishness. If the *electro-motive molecules*, by which the speaker has tried to account for the electro-motive effects of the nerves, muscles, and electrical organs,—*viz.* minute centres of chemical action, all arranged regularly so as to turn homologous sides the same way,—are conceived to act upon each other electrically, mutually determining their position of equilibrium and controlling their deviations from it, in such a system, though electricity were the connecting link of the whole and the means of transmitting power through it, the rate of transmission would be independent of that of electricity, and might in proportion to it be almost infinitesimal; it might, indeed, be what the rate of transmission of the nervous agent really is.

---

* Plantamour et Hirsch, 'Détermination télégraphique de la différence de longitude entre les Observatoires de Genève et de Neuchâtel.' Genève et Bâle, 1864. 4°, p. 89.

The speaker concluded by exhibiting a model of such a system in which the electro-motive molecules were represented by astatic needles; a more detailed account of which, however, cannot well be given here.

[E. D. B.-R.]

WEEKLY EVENING MEETING,

Friday, April 20, 1866.

John Peter Gassiot, Esq. F.R.S. in the Chair.

G. A. Macfarren, Esq.

On the Music of the Church of England.

Though not educated in a church choir, nor ever having held a church engagement, my discussion of the present subject is justified by my regard for its great artistic importance, being confident that, whatever views I may advance, these are wholly impersonal and prompted only by general interest in the advancement of music in its application to ecclesiastical uses.

England has a National Church. Our best claims to a national school of music, and her best hopes of its development, are in ecclesiastical composition. These are based on the peculiarity to this country of our several forms of church music; our setting of the so-called Service is as different in structure from the Roman Mass as from the Lutheran church cantata; our Psalm tune is equally unlike the Gregorian chant and the Lutheran hymn; and our chant has no parallel.

The objects of church music are:—1st, to stimulate devotional feelings; 2nd, to express them.

The importation of music into the western church, by St. Ambrose, archbishop of Milan, A.D. 374, was at the instigation of Flavian, bishop of Antioch. If the antiphonal form of singing was, in the church, a direct continuation of Jewish practice; or if the Greeks had before the time of Thespis adopted it for their dramatic choruses from Oriental precedent; certainly the music that was sung was that of the Greek theatre. The proofs of this are: 1st, that the musical scale was divided, by the ancient Jews and the nations among whom they sojourned, into smaller intervals than those of the Greek diatonic genus, whereas the Ambrosian chant exactly accords with this genus; 2nd, that the four modes employed by St. Ambrose—the Dorian, the Phrygian, the Lydian, and the Mixo-Lydian—are identical with the Greek modes so named, and are applied, in ecclesiastical use, each to the expression of the same sentiment as in the Greek theatre. To pretend that St. Ambrose founded a new system of music, that superseded the labours of Pythagoras, Aristoxenes, and their rival partisans, would be to ascribe to him greater powers as a philosopher than those he evinced as an advocate and as a bishop. St. Ambrose was an innovator in incorporating music in the service of the church, and he appropriated the pagan music which was accessible to his congregation, and indeed familiar.

There being no definite method of notation, the melodies of the Ambrosian chant became corrupted through their traditional transmission, when another innovator, St. Gregory the Great, A.D. 590, purified the musical system—the principles of which had, in the meantime, been elaborately expounded by Boëthius, upon the authority of the best Greek writers—added four additional modes of the Greeks to those of Ambrose, and perpetuated his revised and extended system by inventing a method of notation.

Several centuries later, in accordance with the principle of innovation, which always directed the appropriation to ecclesiastical use of what was best for the purpose, harmony was introduced in the form of extempore descant upon the Gregorian chant; and long after this, the rules of written counterpoint were instituted.

The ruling principle of the Reformation in England was to mould the church service into a form "*to be understanded of the people.*" This was carried out, at first, in the translating of the Latin prayers, &c., into the vernacular of the country; and, in course of time, by the Anglicising of the music. John Marbeck, by Cranmer's direction, adapted the English version of the canticles, creed, &c., to the Ambrosian chant, A.D. 1550. The effect of this crude melody in bald unison must have been uncongenial to the people, who, from Saxon times, had always a fondness for simple harmony, to gratify which, the responses were, in the time of Elizabeth, harmonized by Tallis and others, for the uses of different cathedrals. The original Roman plain song for the canticles, &c., was subsequently harmonized by Tallis; and, still later, original music was set to these portions of the service by several composers, whose example has been followed by church musicians down to the present time, though, for the most part, with little regard to the primal purpose, which was, that the people should participate in the performance.

The Anglican chant was originated for the singing of the unmetrical Psalms in English, for which it is better fitted than any other musical form.

The singing of metrical hymns was at all times a prominent feature in the worship of religious reformers; the Waldenses, the Lollards, the Hussites, the Lutherans, the Calvinists, had each their metrical hymns, in the performance of which all members of their community took part. The practice became general in this country at the period of the Reformation. but, at first, as a substitution for the obscene songs that were common among the people. It was in the hope to purify their mouths of these gross and profane subjects, that Thomas Sternhold, groom of the robes to Edward VI., versified some of the Psalms, adapting his metres to the ballad tunes of the day; and these versified Psalms were printed, without music, in 1549. The desire to sing hymns in the celebration of the service became so strong among the people, that in the 49th injunction of Elizabeth, in 1559, it is expressly ordained that this practice should be "permitted" in churches; in consequence of which, the versification of the Psalms, begun by Sternhold, was completed by

Hopkins and others, and the whole Book of Psalms in metre, with appropriate tunes—some of continental origin, some of English composition—was printed in 1563. These tunes were published without harmony; but in 1564 another edition was printed, in harmony for four voices, by various composers. The love of psalm-singing grew more and more general, as is proved by the many collections of harmonized tunes that followed this, and by Bishop Jewel's statement, that four or five thousand persons, assembled to hear the preaching at Paul's Cross, would all join in the hymn or psalm at its conclusion. The word anthem is substituted for hymn in the later Prayer Book of Elizabeth. This term is, by many writers, derived from Antiphone, somewhat anomalously, since it is the only part of the service that is not usually antiphonal. Dr. Johnson, more plausibly, traces it to Antihymnus; but the etymology of the Rev. J. P. Metcalf is to be preferred, which assigns its origin to Antithema, implying that it at first denoted free counterpoint against a given theme—the harmony to the psalm tune—analogous to Motet, the *motettus* or moving part against the Cantus Fermus of the Roman Church. Several illustrations of this definition prove the concise character originally purposed for the anthem, and point to the dereliction from this in the lengthy and complicated compositions of later times.

The corruption of English church music had its root in the retention of the precentorship as a priestly office at the time of the Reformation, the period at which the study of music, like all other civil studies, first became common among the laity. When music, the most modern of the arts, was in its embryo, the mastery of its few dogmatical rules was easily compatible with the study of theology, and hence it was as proper for the precentor to be a clerical officer as for the dean, his only capitulary superior; but, now that the resources of this art are seemingly unlimited, now that the discovery of the natural principles which govern it has given it a scientific basis, its full comprehension engrosses the labour of a whole life, and the exceptions are most rare of persons who can attain to its knowledge as a relaxation from the pursuit of another profession. The effect of this great fundamental evil was not felt till much later: but there can be now no question of the impropriety of committing the entire control of the singers, the choice of the music, and every arrangement and responsibility of this highly important element of the church service, to an officer who is not compulsorily acquainted with music. That some few precentors have a knowledge of the subject which it is their duty to direct, only aggravates the ill-working of the system; since it gives countenance to the very many more who are equally ignorant and either indifferent or prejudiced. The result of this much to be regretted system is the official neglect of cathedral music, the reduction of the numbers in the choirs, the ill esteem and consequent degradation of the choristers, the often slovenly and always meagre performance of the service, and—worst of all—the frequent aggravation of the evil by ill-directed designs to remedy it.

The music in parochial institutions has suffered, in proportion, from the control of non-musicians; and, though measures be taken for its improvement, no measures can be efficient that are not confided to persons whose education has qualified them for their fulfiment.

The contributions to psalmody by persons with little musical education, or with none, began early in the last century, and have tended seriously to vulgarize and emasculate this noble branch of church music. The misappropriation of the glee style of writing to church composition has done equally much to deteriorate the music special to the cathedral. The admission of solo anthems has tended to make the church an arena for the display of the singers and for the indulgence of the audience, who have attended service more for the amusement of criticism than for the edification of prayer. The adaptation of irrelevant words to music from the florid masses of composers of later times, from oratorios and from instrumental works, has perverted the composer's designed expression, which is the highest quality in music, and has thus degraded the art and its influences. The adaptation of secular melodies as hymn tunes cannot be too strongly deprecated, since they are never divested of their secular associations. The introduction of compositions by clerical amateurs or their friends, whose social position has commanded attention to their productions, has often made the church a medium for the gratification of vanity, at the expense of genuine artistry. The attempt to revive the use in the church, of the Greek system of music—which Ambrose introduced and Gregory continued, because there was then none other accessible, produces, if not an affectation of sanctity, at least a pedantic assumption of antiquarianism that is as remote from devotion. Moreover, this is in direct contradiction to the principle of the Reformation, since the Greek, or as it is called, the Ecclesiastical modes are not "understanded of the people," and it would not be more opposed to the spirit of the Church of England to make the people pray in Latin, than to make them sing in the dead language of a musical system that is wholly superseded.

The capabilities of church music, for the attainment of its two great objects, are only to be limited by the genius and artistic cultivation of the musicians who may devote themselves to its production and performance, where these are not thwarted by the non-musical authorities. When either of the fine arts is admitted into sacred uses, the utmost possible endeavour should be made to present that art at its best. The ambition of the ablest composers should therefore be stimulated to seek their highest distinction in writing for the church, not in an assumed manner that was once general for all subjects, and is now conventionally considered as sacred, but in the style characteristic of their own time, which, as such, will naturally best express their own emotions and best appeal to the emotions of others, and distinguished from their own secular music by its greater elevation of purpose and earnestness in the fulfilment of this; such has been the case with sacred music from the madrigal era to our own time;

and the examples of Orlando Gibbons, Purcell, Bach, Handel, and Mendelssohn, are safe precedents. Notwithstanding very strong prejudice to the contrary, the fitness for oratorios for performance on particular occasions in sacred edifices, merits earnest consideration, if not their unfitness for performance elsewhere; it being remembered that the oratorio, in one of its forms, was originated by Giovanni Animuccia, for performance at the oratory meetings of S. Filippo Neri, in the church of S. Giovanni Laterano, A.D. 1556; and in its other form by Emilio Cavaliere, for performance in the church of Santa Maria, in Valicella; that the master-pieces of Bach were written for the celebration of the Passion in the Lutheran church, and that the oratorios of Handel were first given in public with apologies for their performance in a secular building. Every pains should be taken to promote choral singing among the laity, but no person should be permitted to participate in congregational singing who had not joined in a periodical practice for the same, or given proof of qualification. The perfection of the plastic arts in Greece was attained by the endeavour to do honour to the national religion; the perfection of Gothic or Christian architecture resulted from the same purpose: be the hearts of artists attuned to this glorious task, and the music of the Church of England may approach that perfection towards which musical art at present seems to need some such stimulating impulse.

[G. A. M.]

WEEKLY EVENING MEETING,

Friday, April 27, 1866.

His Royal Highness The Prince of Wales, K.G. F.R.S.
Vice-Patron, in the Chair.

The Very Rev. Arthur Penrhyn Stanley, D.D. F.R.S.
Dean of Westminster.

On Westminster Abbey.

"Like some tall palm the noiseless fabric sprang,"

was the well-known line of Reginald Heber, describing the rise of Solomon's temple.

"Like some tall palm" not only the Jewish temple, but many a Grecian temple, many a Roman basilica, has sprung into existence. The growth of Westminster Abbey requires a more complex figure to do justice to its formation—a venerable oak, with gnarled irregular growth, and spreading roots, and decaying bark, and twisted branches, and hollow trunk, and feeble shoots — the very counterpart of our English history in Church and State.

There is one point in which, without any false pride, I may say that Westminster Abbey stands alone amongst the buildings of the world. There are of course many which surpass it in beauty or grandeur,—many which surpass it in the depth or sublimity of trains of association; but none have been entwined by so many long continuous threads of diverse elements with the history of a whole nation.

It is obvious that this complexity of interest makes it impossible in any single lecture to do more than treat one single part of the subject. I might trace its gradual origin, from its geographical situation in the Isle of Thorns; from the charm of the name of St. Peter; from its neighbourhood to the palace of Westminster; from the strange enthusiasm of Edward the Confessor. I might show how architecturally it represents the three great epochs of our national buildings; how under its first founder it was the earliest monument of Norman, European civilization planted on our barbarous Anglo-Saxon soil; how under its second founder it was intended to be, and was, the most complete and beautiful specimen of the most beautiful style that the middle ages produced; how under its third founder it exhibits the last magnificent decay of medieval art, in the Chapel of Henry VII. I might describe its close connection with the whole course of English history, how it has witnessed the coronation of all, the burial of far the larger number, of our sovereigns from the Conquest downwards; how, whilst it has been the seat of royalty, it has been the cradle of liberty; how out of its erection directly sprang, and within its precincts was first sheltered, that great assembly which at this very moment concentrates on itself the thoughts of the whole nation.

I might describe all the various assemblies and institutions which it has thus guarded under its wings, not only the House of Commons, but the ancient Treasury of England; the first English printing-press; the early Councils of Westminster, the Westminster Assembly of Presbyterian divines, the Convocations of the province of Canterbury. I might show how it is the seat of the great school which has endeared the name of Westminster to the earliest years of so many illustrious Englishmen; how it has been the seat of the most honourable, the most ancient, and the most meritorious order of English knighthood. I might describe its peculiar jurisdiction—its venerable sanctuary, the refuge of kings as well as of outlaws; its political position and its religious functions as the metropolitan church of the great city of Westminster; the long succession of abbots and of deans, with the privileges and exemptions which render them and the institution over which they preside one of the most peculiar in the Church and State of England.

I might follow the kind hint thrown out to me by a well-known Gazette yesterday evening, and lay before you for the consideration of the Government and the public—what I fear would be somewhat more dry—Mr. Gilbert Scott's estimates for the restoration of the great northern porch, the restoration of the Chapter House, and the building of a magnificent cloister at the south-east corner of the Abbey; or a statement, drier still, of what the Dean and Chapter have been doing and are doing, with all the means in their power, for the preservation, reparation, and adornment of what already exists; or the assurance, driest of all, that they have taken every precaution which the highest professional authorities can advise to ensure the venerable Abbey against the slightest danger from the subterranean Metropolitan Railway.

I have thought it best, however, to take one other single aspect of the whole subject: its importance as the burial-place of our celebrated men. It is this aspect, more than any other that I have named, which most endears it to the mass of our countrymen. It is this that, more than any other, won for it the delightful visits of Addison, in the 'Spectator;' of Steele, in the 'Tatler;' of Goldsmith, in the 'Citizen of the World;' of Charles Lamb, in 'Elia;' of Washington Irving, in the 'Sketch-book.' It is this which intertwines it with so many eloquent passages in the writings of Macaulay. It is this which inspired the saying of Nelson—"a Peerage or Westminster Abbey." It is this which has twice within the present year given point to the speeches of one of our statesmen least likely to draw his illustrations from ecclesiastical buildings. It is this which still gives most promise of vitality and immortality to the whole institution. Kings are no longer buried within our walls; even the splendour of pageants has ceased to attract; but the desire to be commemorated amongst the dead in Westminster Abbey is still as strong as ever.

And yet, on the other hand, this very peculiarity is the one which exposes the Abbey to the most severe criticism and attack. There are not a few who would wish, as the first step to any restoration, to clear out from its venerable walls the strange pile of heterogeneous monuments which disfigure its beautiful architecture; who complain, not without reason, of the unequal value and unequal fame of the monuments themselves; who protest against the intrusion into a Christian church of grotesque forms and inappropriate inscriptions, such as exist in no like degree elsewhere.

It is to meet these conflicting tides of emotion, to act partly as a guide through this interesting and intricate labyrinth, partly as an apologist for these monumental stumbling-blocks and stones of offence, that I propose to give a brief history of the growth of this part of our institution, and to show that if ever it is to be cleared, it must be touched with the tenderest care; if it be a parasitical growth, it is one which has struck its fibres so deep into the building, that if you tear it rudely out you will perchance bring down the entire edifice with it. Sooner or later the pruning must take place; but for that very reason let us well consider the whole relation of this sacred mistletoe to the parent tree.

In taking this subject, "I have left," if I may use the words of Addison, "the repository of our English kings for the contemplation of another day, when I shall feel my mind disposed for so serious an amusement." But there is a general consideration of the royal tombs of Westminster which lies at the root of all that I shall have to say of the private tombs.

There are two great peculiarities which distinguish them from royal sepulchres in any other part of the world. First, Westminster Abbey is connected not only with their deaths but their lives; it unites their coronations with their burials.

. . . . . "That antique pile behold
Where royal heads receive the sacred gold;
It gives them crowns, and does their ashes keep;
Here made like gods, like mortals here they sleep:
Making the circle of their reign complete,
Those suns of empire, where they rise, they set."

And this striking connection is rendered more impressive from its growth out of a noble characteristic of our English monarchy. The Kings of England, unlike the sovereigns of other countries, never seem to have feared the sight of death. The Kings of France not only did not live at St. Denys, but never went there. Louis XIV. chose Versailles for his residence instead of St. Germains, because from the terrace of St. Germains he could see the hated towers of the sepulchral abbey. But the Anglo-Saxon kings were usually buried at Winchester, where they also usually held their Court. The English kings, as soon as they became purely English, were buried, as they had lived, at Westminster. As now they lie under the shadow of their proudest regal residence, in St. George's Chapel, or in the precincts of Windsor Castle, so in former days they lay in the very closest neighbourhood to their palace, and in the very midst of the life of their people.

And this led yet further to the aspect of the Abbey which we have now to consider. Had they been buried far away in some conventual or secluded spot, or had the English nation stood aloof from the English monarchy, it might have been otherwise. The sepulchral chapels built by Henry III. and Henry VII. might have stood alone in their glory: no meaner dust need ever have mingled with the dust of the Plantagenets, Tudors, Stuarts, and Guelphs. The Kings of France rest almost alone at St. Denys. The Kings of Spain, the Czars of Russia, the Emperors of Austria, rest absolutely alone in the vaults of the Escurial, of Moscow, of St. Petersburg, of Vienna. But it has been the peculiar privilege of the Kings of England, that neither in life nor in death have they been parted from their people. As the council of the nation and the courts of law have pressed into the palace of Westminster, and engirdled the very throne itself, so the ashes of the great citizens of England have pressed into the sepulchre of the kings, and surrounded them, as with a guard of honour, after their death. You may remember the tomb of Maximilian at Inspruck, where the Emperor's effigy lies encircled by the mailed figures of ancient chivalry, of Arthur and Clovis, of Rudolf and Cunegunda, of Ferdinand and

Isabella. A noble thought—yet not so noble as that which is in fact realized in the very structure of Westminster Abbey, as it is in the very structure of the English constitution. When you are inclined to contrast the placid dignity of our recumbent kings with Chatham, gesticulating from the northern transept, or Pitt from the western door, or Shakespeare leaning on his column in Poets' Corner, or Wolfe expiring beside the Confessor's Chapel, look upon them as each in their different ways keeping guard over the shrine of our monarchy and our laws,—and that which seems at first incongruous will then become a symbol of the harmonious diversity in unity which pervades our whole commonwealth.

Had the abbey of St. Denys admitted within its walls the poets and warriors and statesmen of France, who can say but that the kings might yet have remained inviolate in their graves? Had the monarchy of France connected itself with the great institutions of Church and State, assuredly it would not have fallen as it did in its imperial isolation. Let us accept the omen for the Abbey of Westminster; let us accept it also for the Throne and State of England.

It was only by slow degrees that this peculiarity of Westminster Abbey developed itself: in this respect, also, the counterpart of the irregular, uncertain gradual course of English history. There is no moment at which we can fix the date when the idea of its becoming the national burial-place was formed, although we can trace the successive moments of its formation. The very idea was new. It is the earliest cemetery of the kind in Europe—we may say in the world; for in classical times, such a segregation of the ashes of the greatly gifted from the ordinary mass of men was unknown; and in the middle ages, so far as it existed at all, it was confined to canonized saints. No theory of the kind existed when the Confessor procured the first privileges of the Abbey, nor yet when Henry III. planned the mausoleum of the Plantagenets; nor even when Henry VII. laid the foundation of the mausoleum of the Tudors.

The first intruders into the sacred floor were the immediate favourites and retainers of the sovereigns. It was the burial-place of the retainers of the adjacent Court of Westminster, just as now the precincts of St. George's Chapel contain the burial-place of the immediate dependents of the Castle of Windsor.

Hugolin, the Confessor's chamberlain, leads the way—the terrible financier who kept in check the mild benevolence of the child-like king. But he lies outside in the cloisters. He lies hard by the ancient treasury, which he guarded so well—the tutelary genius of that august vault, which still can only be entered by the sixfold keys of the Lords of the Treasury and the Chancellor and Controller of the Exchequer.

It is characteristic of the unbounded favouritism of Richard II., that the first who actually reached the interior of the church were those whom he thus honoured amongst his courtiers. Out of that temporary evil, sprang up, as often happens, an immense permanent good.

The first was John of Waltham, his treasurer, who, amidst the indignant murmurs of the outside world, was buried in the Confessor's chapel itself. His brass effigy can still be seen breaking up its mosaic pavement, the venerable forerunner of all the statesmen in the Abbey. The second, his tutor, Robert Waldby, at once physician and divine—and thus the venerable forerunner of all the men of letters and science—lies in the chapel at that time next in dignity to the chapel of St. Edward, the chapel of the other royal Anglo-Saxon saint, St. Edmund. It is not without importance in the history of the Abbey to note this circumstance. Next to the immediate neighbourhood of the altar and the shrine of the patron saint, the most sacred chapels were built on the south or sunny side, and accordingly the personages who by rank or power approached most nearly to the king's person, were interred in the two immediately adjoining the Confessor's chapel on the south, of which the sanctity of at least the first was yet more distinctly marked by the saint to whom it was dedicated. The two royal Anglo-Saxon saints especially honoured by Henry III., were Edward the Confessor, after whom he called his eldest son Edward, and Edmund the Martyr, after whom he called his second son. In this and in the adjacent chapel of St. Nicholas, were interred the lesser princes and princesses, and the succeeding courtiers of the Plantagenet kings.

It is in the age of Elizabeth that the first large increase took place in the private monuments—the first distinct recognition of the Abbey as a Temple of Fame. Her favourites were heroes and heroines, literally verifying Gray's description of her court:—

> " Girt with many a Baron bold,
> Sublime their starry fronts they rear;
> And gorgeous dames, and statesmen old
> In bearded majesty, appear."

From that moment the chapels all round the Confessor's shrine, including those on the less frequented northern side, start into life, with the tombs of Burleigh and Russell, and the warriors of the Flanders campaign, all except the one unforgotten hero of those now forgotten wars, Sir Philip Sidney, who sleeps at St. Paul's, the forerunner by a long interval of Nelson and Wellington. In them the first-fruits of England's naval and military glory, by the special grace of the Virgin Queen, were offered up in the royal Abbey. Then, amidst many dark shades and stormy lights, follow the less worthy courtiers of James and Charles. The towering grandeur and the tragical fall of George Villiers, Duke of Buckingham, is marked not only by the august monuments of his parents and of himself, but by the fact that he, first of any subject not of royal descent, was deposited in the Chapel of Henry VII.

Then comes the strange period in the history of the Abbey which more than any other indicates the strong hold which it had laid on the national feelings. Not only did Cromwell prepare the vault for the sepulchre of himself and his family in Henry VII.'s chapel (this might have been regarded as a purely dynastic ambition), but the grandees of the Commonwealth, to whom it might have been thought that the last home of royalty would have been in the highest degree distasteful, could not part with the link which united them with the Abbey.

Indeed, this more than any other single epoch must be selected as the point in which the thought of making the Abbey the mausoleum, not only of kings, but of heroes, became firmly and ineradicably fixed in the public mind.

Pym and Strode, the leaders, and May, the historian of the Long Parliament, Ireton and Bradshaw, the regicide chiefs, the Parliamentary divines of the Westminster Assembly—and last, not least, the great Admiral Blake, founder of our naval empire, were amongst those worthies; he, by the desire of the Protector, was brought from Plymouth, where he died (to use the words of Clarendon), "with all the state that could be, to encourage his officers to venture their lives, that they might be pompously buried, and he was, with all the solemnity possible, and at the charge of the public, interred in Henry VII.'s chapel, among the monuments of the kings."

This is the first distinct assertion that interment in Westminster Abbey was, like ancient knighthood or modern peerage, an incentive to heroic deeds.

These great men, by what Dr. Johnson justly calls "the mean revenge" of the Restoration, were cast out of the Abbey. They still, however, repose beneath its shade, and the impulse their burial gave to its historical glories transmitted itself to the next generation with a force that has gone on increasing ever since.

The crowd of monuments takes a new start after the Restoration and Revolution. The warriors, for the most part, are where Sir Roger de Coverley saw them, in the nave and in the northern chapels, and in one or other of those spots they have always continued to be laid. The statesmen, after the example of the Commonwealth, were allowed to throng the vacant spaces in Henry VII.'s chapel till no more remained. By the middle of the eighteenth century the race of English statesmen not only had increased in importance, but also had become so much more of a class separate from the mere magnates of the court or camp, as to require, if possible, a separate resting-place. In this the history of the Abbey and the history of England alike coincided. At that same juncture, every important part of the church was more or less occupied, with one exception. The northern transept, like the northern side of a country churchyard—like the Pelasgicum under the dark shadow of the north wall of the Athenian Acropolis—had remained in comparative solitude; but, like the Pelasgicum under the pressure of the Peloponnesian war, this too was now to be occupied. One great name determined its fate for ever. For the body of William Pitt, Earl of Chatham, the two great sepulchral churches of the metropolis contended; but Parliament decided against St. Paul's and in favour of Westminster, on the ground that the imperial statesman should be brought near to the dust of kings—and Chatham, accordingly, was buried with almost regal pomp in the vault by the northern entrance. From that time the northern transept has been appropriated to the burial of statesmen. "In no other country," says Macaulay, "do so many great citizens lie within so narrow a space. High over those venerable graves towers the stately monument of Chatham, and from above, his effigy, graven by a cunning hand, seems, with eagle face and outstretched arm, to bid England be of good cheer and hurl defiance at her foes;" that eagle face "which seemed to Wilberforce, as he bore the banner before the hearse of the second Pitt, to look down from above with consternation into the dark house which was receiving all that remained of so much power and glory."

"Death," as Bossuet finely says, "is closing up the ranks," and already a new statesmen's corner (the Whigs' corner, as it is sometimes called) is forming in the north-west corner of the nave, near the monument of Fox; but whether there or elsewhere, I trust that the time will never come when the succession of English statesmen, of whatever party, will look to any other place than the Abbey as their long last home.

From the north transept I turn to the south. This, the sunny, propitious side of the Abbey, had already been long filled before the occupation of its counterpart on the north. The fate of this, too, was determined by a single grave.

In the time of Henry IV., in the first year of the fifteenth century, there was laid in this transept, doubtless from his official connection with the Court, the Clerk of the Works at Westminster. That Clerk of the Works, thus humbly interred in what was then the outer court of the temple, was Geoffrey Chaucer. The simple slab of gray marble which covered his grave—broken up, alas! two centuries ago—was the first nucleus of Poets' Corner. But, if it was merely an accidental connection which brought him within that close proximity to his royal masters, the sense of the royal character of genius clenched the prominence thus gained. Henceforth, as one of themselves expressed it—

> "Our poets near our princes sleep,
> And in one grave their mansion keep."

Accordingly, in the great burst of Elizabethan literature, this was the spot to which Spenser was naturally brought. The wish which he had expressed in his life, to follow "Dan Chaucer, well of English undefiled," was distinctly carried out in the original epitaph on his gravestone:—*Hic prope Chaucerum* situs est Spenserius ille Proximus ingenio, proximus et tumulo."

And it is over his grave that the cry arose on the death of a greater than either:—

> "Renowned Spenser—lie a thought more nigh
> To learned Chaucer—and rare Beaumont lie
> A little nearer Spenser—to make room
> For Shakespeare in your threefold fourfold tomb."

Shakespeare, it is true, came not, nor was his monument erected even till years afterwards. But the sacred line was never broken. The quaint expression of Fuller has become more appropriate with each succeeding generation: that "this royal company of poets in the southern transept of Westminster Abbey is enough almost to make passengers' feet move metrically, who go over the place where so much poetical dust is interred." If a new Poets' Corner should be needed, a single name has again predestined the spot. In the south-west corner of the nave the religious feeling of a near kinsman has fixed the statue of Wordsworth, beside the font in the baptistry. There may many a childlike spirit catch its first impression of the purest and simplest of English poets,—the fitting Chaucer of a new generation.

Close beside the poets, yet distinct from them, gradually rose another group of tombs. Isaac Casaubon, scholar, divine, and historian, "lieth entombed," I again quote Fuller, "in the south transept of Westminster Abbey;" and then he adds, with an emphasis which marks the first in a new and long succession, "not in the east or *poetical* side thereof, but in the west or *historical* side of the aisle." Immediately following, and immediately adjoining, so as to continue and confirm this idea, is the memorial of Camden. "Both of them," I must use the words in which Fuller describes their appearance in his day, "both plain tombs, made of white marble, show the simplicity of their intentions, the candidness of their natures, and the perpetuity of their memorials."

The historical branch could not be kept long apart from the poetical branch which grew so near. Gradually the south transept became equally devoted to them both. Their junction in the same corner of the Abbey is a proof of the instinctive need for the indissoluble union of fact and poetry, of learning and imagination; and when the last grave was opened in that aisle to receive the remains of Macaulay, although he fitly lies on the historical side of the transept, yet his companionship would not have been disdained by the brightest and loftiest of the poets who look down upon his tomb from the opposite wall. The union of the historical and poetical corner in the Abbey is a standing protest against the vulgar literary heresy which denies Clio to be a Muse.

Connected with the historians and poets is a group of celebrities whose introduction into the Abbey has a peculiar signification of its own. There is a remarkable passage in Mr. Lecky's 'History of Rationalism in Europe,' in which he contrasts the conduct of the French and English churches towards dramatists and actors: whilst the great French actors were buried with the burial of dogs, the great English actors, during the whole of the last century, were interred without a murmur in our chief sanctuary. Of all the visits recorded to the Abbey, next after Addison in the 'Spectator,' the most impressive is the account which Steele, in the 'Tatler,' gives of his waiting in the cloisters for the funeral of Betterton. In those cloisters, perhaps, or in the nave, from a natural sense of congruity, was buried, rather than in the transept, that first of English actors, with some of his compeers; but they soon reached the interior portions of the church. Garrick lies—where else could he lie?—at the feet of Shakespeare. Charles Kemble took his place amongst the statesmen: I trust that I shall be considered to have exercised a not unwise discretion in having moved him to the chapel of St. Andrew, by the side of his sister, Mrs. Siddons.

This admission of actors is an amount of tolerance against which not only the religious world, but the gentle and genial spirit of Charles Lamb lifted up his voice; but the same eminent writer whom I just now cited, has truly said that "this forbearance of the Church of England towards the stage has received its reward; and that, if we except the short period after the Restoration, the English theatre has been that in which the moralist can find least to condemn."

Closely connected with the lessons of the stage come the musicians—in their first beginnings equally balanced between the Theatre and the Church. They, too, in the person of Henry Lawes, the friend of Milton, first appear in the cloisters, but finally find their Musicians' Corner where it was most fitting—in the north aisle, behind the organ—as it was inscribed on the grave of the first and most illustrious who was there interred, Henry Purcell, "dum vicina organa spirant," "where the neighbouring organs breathe." One only, greatest of all, stands apart from his musical brethren, in Poets' Corner. Handel, the author of the 'Messiah,' was not unfitly interred amongst the prophets of English song.

With the musicians the history of art in the Abbey exhausts itself. The sculptors and architects are only very imperfectly represented, painting not at all, with the single exception of Sir Godfrey Kneller, whose monument is here against his will, and as the result of a personal quarrel at Twickenham. Sir Joshua Reynolds's burial in St. Paul's has carried with it the commemoration of all future painters to that great cathedral.

It is a proof of the slow and gradual growth of science in England that it has not appropriated to itself any special place in the Abbey, but has penetrated promiscuously and imperceptibly into every part, much as it has in like manner influenced all our social and literary relations.

Sir Isaac Newton was the first. It must, perhaps, be said that of all the graves in the Abbey, his is the only one which retains the dust of an absolutely world-wide fame. The place that was given to him was in proportion to the just admiration for his prodigious genius. It was that conspicuous spot, coveted by many nobles and statesmen, on the right hand of the entrance of the nave from the choir. It may be that this was the cause of the attraction of other scientific men round the walls of the nave—Conduitt, Folkes; then that splendid generation of illustrious physicians who, in that age, as some of their successors in our own, combined with their healing art the keenest interest in scholarship and science—Chamberlen, Woodward, Mead, and Freind. From that time the memorials of the victories of science spread irregularly from chapel to chapel, till they culminated in the gigantic monument of James Watt. Of all the monuments in the Abbey, perhaps this is the one which calls forth the loudest execration from those who look only for congruity or uniformity of design. Well might the ancient pavement of the church crack and yawn, as it did, when the enormous monster moved into its place, disclosing rows upon rows of gilded coffins in the vaults beneath. Well might the standard bearer of Agincourt and the stately worthies of the courts of Elizabeth and James have started from their tombs in the chapel of St. Paul as they saw this colossal champion of a new plebeian art enter their aristocratic resting-place, and take up his position in the centre of the little sanctuary, regardless of all proportion or style in the surrounding objects. Yet when we consider what this vast figure represents—what worlds of interest before unknown, what revolutions in the whole outward framework of modern society lie in that capacious lap—there is surely a fitness even in its very incongruity. If it be an exaggeration, it represents an exaggeration which has almost overrun the Abbey itself, and which meets us in street and field, on sea and land, down vale and over hill, from end to end of the civilized world.

I have thus gone very rapidly through the monumental structure of the Abbey. It is the mere skeleton, or rather joints of the skeleton. The flesh and colour and features would require hours to describe. But there are a few general remarks which this rapid survey suggests.

1. First, observe how extremely irregular, and, as it would seem, capricious, is the commemoration, or absence of commemoration, of our famous men. It is this which renders the interment or notice within our walls an uncertain honour, and makes the Abbey itself a very imperfect mausoleum of greatness. But it is this also which gives to it that perfectly natural character of which any artificial collection is entirely destitute. In the Valhalla of Bavaria, every niche is carefully portioned out, and if a single bust is wanting from the catalogue of German worthies, its absence becomes the subject of a literary controversy, and the vacant space is at last filled. Not so in the Abbey: there, as in English institutions generally, no fixed principle has prevailed. Graves have been opened or closed—monuments erected or not erected, from the most various feelings of the time. It is the general wave only that has borne in the great celebrities. Viewed in this way, the absences of which I speak have a touching significance of their own. They are eloquent of the force of domestic and local affection over the desire for metropolitan or cosmopolitan distinction—eloquent of the force of the political and ecclesiastical prejudice at the moment. Why are men so famous as Burke or Peel amongst statesmen, as Pope or Gray amongst poets, not in the Statesmen's or the Poets' Corner? Because the patriarchal feeling in each of these men—so different each from the other, yet alike in this—drew them from the neighbourhood of the great, with whom they consorted in the tumult of life, to the graves of father and mother, or beloved child, far away to the country church-

yards of Twickenham, Stoke Pogis, Tamworth, Beaconsfield—in each perhaps not unmingled with the feeling which is expressed in Pope's epitaph on himself at Twickenham, "for one that would not be buried in Westminster Abbey":—

> "Heroes and kings your distance keep,
> In peace let one poor poet sleep,
> Who never flattered folk like you.
> Let Horace blush, and Virgil too."

Why is it that Montague, Earl of Sandwich, George Monk, Earl of Albemarle, restorers of the monarchy, Archbishop Usher, the glory of the Irish Church, Clarendon, the historian of the Great Rebellion, rest here with no cotemporary monument, three of them with none at all? That blank void tells again in the bare stones the often repeated story of the ingratitude of Charles II. towards those to whom he owed so much and gave so little.

Why is it that Wordsworth and Southey have no grave? Scott and Burns no grave or monument? Because the affection of the two first for their homes by their mountain lakes, the association of the two others with their mother-country, was too strong to be sacrificed to any uniformity in the distribution of sepulchral honours.

Westminster Abbey is, as Dr. Johnson well said, the natural resting-place of those great men who have no bond elsewhere. Its metropolitan position has, in this respect, powerfully contributed to its fame. But even London is or ought to be insignificant compared with England; even Westminster Abbey must at times yield to the more venerable, more enduring claims of home and of race. Those quiet graves far away are the Poets' Corners of a yet vaster temple; or may we take it yet another way, and say that Stratford-on-Avon, or Dryburgh, or Grasmere are Chapels-of-ease united by invisible cloisters with Westminster Abbey itself?

2. Again, within the circle of those who are buried or commemorated here, the selection of particular spots are again and again to be traced to the sentiment of the man or of the moment, rather than to any general plan or permanent scheme. I have shown how the main groups have formed themselves, as it were accidentally, round particular centres of death. But, besides this, the same principle applies in the exceptional details. Why was Atterbury buried at the extreme west end? Because, as he himself said, he wished to lie as far as possible removed from kings and kaisers—from the royal races at the eastern end, to those he had so little reason, either in life or death, to be grateful. Why is Addison buried apart from his tuneful brethren, in the royal shades of Henry VII.'s chapel? Because he wished, and was permitted, to lie in the vault of his own loved Montague, who had achieved his place there by long and powerful statesmanship. Why was Usher buried in the chapel of St. Paul? Because he wished to rest beside his earliest instructor, Sir John Fullerton. Why (to take a less known instance) did the tablet of

Captain Creed, in the Dutch wars, hang where it once did (nor is it now far removed), in the northern aisle of the nave? Because, as the inscription tells us, he used often in life to look at the neighbouring monument, where his kinsman, the Earl of Sandwich, is mentioned, whose virtues he strove to emulate. Why was Vertue, the engraver, buried in the west cloister? Because he was a Roman Catholic, and wished to be interred by a collateral ancestor who had been a monk in the Abbey in its older days. Why was Lord Palmerston's grave chosen exactly where it is, in the northern, or Macaulay's in the southern, transept? Because it was fitting that the one should lie as near as possible to his first patron, Canning; the other, as near as possible to the foot of the statue of his favourite Addison.

These special attractions towards particular graves and monuments may interfere with the general uniformity of the Abbey, but they immensely enhance its interest and its instruction; they make us feel that it is not a mere dead museum, but that its cold stones are warmed with the life-blood of human affections and personal partiality. It is said that the celebrated French sculptor of the monument of Peter the Great, at St. Petersburg, after showing its superiority in detail to the famous equestrian statue of Marcus Aurelius at Rome, ended by the candid avowal, " Et cependant cette mauvaise bête est vivante, et la mienne est morte." Perhaps I may be allowed to reverse the saying, and when I contrast the irregularities of Westminster Abbey with the uniform congruity of Salisbury or of the Valhalla, may say, " Cette belle bête est morte, mais la mienne est vivante."

3. Again, observe how magnificently the strange conjunction of tombs in what has been truly called this Temple of silence and reconciliation exemplifies the wide toleration of Death; may I not add, the comprehensiveness of the true religion of the Church of England? Not only does Elizabeth lie in the same vault with Mary her persecutor, and in the same chapel with Mary her victim; not only does Pitt lie side by side with Fox, and Macpherson with Johnson, and Outram with Clyde, but those other deeper differences, which are often thought to part more widely asunder than any political or literary or military jealousy, here have sunk into the shade. Goldsmith, in his visit to the Abbey, puts into the mouth of his Chinese philosopher an exclamation of wonder that the guardianship of a national temple should be confided to " a college of priests." I do not claim for my predecessors the Deans of Westminster any exemption from the ordinary infirmities of their profession; but the variety of the monuments, in country and in creed, as well as in taste and in politics, is a proof that the successive Deans who have held the keys of St. Peter's Abbey have, on the whole, risen to the greatness of their situation, and have endeavoured to embrace within the wide sympathy of their consecrated precincts, those whom a narrow and sectarian spirit might have excluded, but whom the precepts of their common Master, no less than the instincts of their common humanity, should have bid them welcome. The exclusiveness of Englishmen has given way before the claims of the

French Casaubon, the German Spanheim, the Corsican Paoli. The exclusiveness of churchmen has allowed the entrance of the Nonconformist Watts, of the Roman Catholic Dryden. Courayer, the French priest who ended as an English latitudinarian of the extremest kind—the Blanco White of his day; Ephraim Chambers, the sceptic of the humbler, and Sheffield, the sceptic of the higher ranks, were buried with all respect and honour by the "college of priests" at Westminster, who knew that the bruised reed was not to be broken, nor the smoking flax quenched. Even the yet harder question of high intellectual gifts, united with moral infirmity or depravity, has on the whole here met with the only solution which on earth can be given. If Byron was turned away from our doors, many a one as questionable as Byron has been admitted. The godlike gift of genius was recognized, the baser earthly part was left to the merciful judgment of its Creator. So long as Westminster Abbey maintains its hold on the affections or respect of the English Church and nation, so long will it remain a standing proof that there is in the truest feelings of human nature, and in the highest aspirations of religion, something deeper and wider than the partial judgments of the day and the technical distinctions of sects, —even than the just, though it may for the moment be misplaced, indignation against the errors and sins of our brethren. It is the involuntary homage which perverted genius pays to the superior worth of goodness and of holiness, that it seeks to be at last laid within the building consecrated to the highest and purest hopes of the soul of man; and when we consent to receive such within our walls, it is the best acknowledgment of the truth uttered by our departed Christian poet—

> "There is no light but Thine—with Thee all beauty glows."

There is yet another interest attaching to the tombs, even the worst and humblest, namely, as a record of the vicissitudes of art. Doubtless, this is shared by Westminster Abbey with other great cathedrals and churches. Still the record here is more continuous and more striking than anywhere else. We trace here, better than anywhere else, the gradual rising of the recumbent effigies: first, to lean their heads on their elbows, then to kneel, then to sit, then to rise, stand on their feet, then to gesticulate, then to ascend out of flimsy waves into still flimsier clouds. Every stage of sepulchral attitude is visible, from the crusader of the thirteenth century, with his legs crossed on his stony couch, to the philanthropist of the nineteenth century, with his legs crossed far otherwise, as he lounges in his easy arm-chair. Forgive them: it may be a breach of the rules of medieval art, but it is also the life of the nation, awkwardly, untowardly struggling into upward existence.

We trace also the evanescent phases of the judgments of art, which ought to make the artists and the critics of each successive age if not sceptical, at least modest, as to their own immortality. We are shocked sometimes at the ruthless disregard of ancient days, in which the old altars of the separate chapels were stamped out for t

Reformers or the Puritans. But the same disregard of antiquity reaches back far earlier. *Ecclesiam stravit istam quam tunc renovavit* —was the inscription which long glorified the memory of Henry III. for destroying the venerable Norman church of the Confessor. Henry V.'s chantry absorbed a large part of the tombs of Eleanor and Philippa. The first prodigious intrusion of Pagan allegories, the first reckless mutilation of medieval architecture by modern monuments, is the tomb of George Villiers, the favourite of our first high-church king, the patron and friend of our first high-church archbishop. It was their sanction and influence that began the desecration, as it is now often thought, which to no section of church or state is so repugnant as to the spiritual descendants of those to whom it seemed the height of ecclesiastical propriety.

Or again, look at the enormous structures which Roubilliac raised in the nave to General Wade and General Hargrave. We pass them by with scorn, but a great London antiquary declared of one of them, that "Europe could hardly show a parallel to it,"—and the other was deemed by the artist himself so splendid a work, that he used to come and weep before it, to see that it was put too high to be appreciated. We pass with ridicule the clumsy rocks and the wretched allegories of the latter part of the eighteenth century. Yet the germ of Admiral Tyrrel's maritime monsters may be seen in Addison's plaintive wish, —"that our naval monuments might, like the Dutch, be adorned with rostral courses and naval ornaments, with beautiful festoons of sea-weed, shells, and coral." And listen to the criticisms of a fastidious correspondent of Pope, and observe the remedy which he proposes:—

"I chose a place for my wife," says Aaron Hill, "in the Abbey cloisters—the wall of the church above being so loaded with marble as to leave me no room to distinguish her monument. But there is a low and unmeaning lumpishness in the vulgar style of monuments which disgusts me as often as I look upon them; and, because I would avoid the censure I am giving, let me beg you to say whether there is significance in the draught, of which I enclose you a copy. The flat table behind is black, the figures are white marble. The whole of what you see is but part of the monument, and will be surrounded by pilasters, arising from a pediment of white marble, having its foundation on a black marble mountain, and supporting a cornice and dome that will ascend to the point of the cloister arch. About half-way up a craggy path, on the black mountain below, will be the figure of Time in white marble, in an attitude of climbing, obstructed by little Cupids, of the same colour; some rolling stones into his path from above, some throwing nets at his feet and arms from below; others in ambuscade, shooting at him from both sides; while the Death you see in the draught will seem, from an opening between hills in relievo, to have found admission by a shorter way, and prevented Time at a distance."

Look at the monument of General Wolfe, and then tremble for the narrow escape which we have had that it did not thrust itself into the place of the exquisite mediæval tomb of Aymer de Valence, nephew of Henry III., as it actually did with the tomb and screen of Abbot Estenby.

"I will give you one instance that will sum up the vanity of great men, learned men, and buildings altogether. I heard lately, that Dr. Pearce, a very learned personage, had consented to let the tomb of Aymer de Valence, Earl of Pembroke, a very great personage, be removed for Wolfe's monument; that at first he had objected, but was wrought upon by being told that *hight* Aymer was a Templar, a very wicked set of people, as his lordship had heard, though he knew nothing of them, as they are not mentioned by Longinus, and I wrote to his lordship, expressing my concern that one of the finest and most ancient monuments in the Abbey should be removed, and begging, if it was removed, that he would bestow it on me, who would erect and preserve it at Strawberry Hill. After a fortnight's deliberation, the bishop sent me an answer, civil indeed, and commending my zeal for antiquity! but, avowing the story under his own hand. He said that at first they had taken Pembroke's tomb for a Knight Templar's,—that, upon discovering whose it was, he had been very unwilling to consent to the removal, and at last had obliged Wilton to engage to set the monument up within ten feet of where it stands at present."

In this attack on my good predecessor, Horace Walpole had all the world on his side, and possibly the world's judgment is now fixed for ever. Yet, perhaps, if some successor of Dean Pearce were now, in the enthusiasm of modern restoration, to remove General Wolfe, I am not sure whether he might not incur the wrath of some future Walpole, the ridicule of some future Royal Institution.

There are, doubtless, "lumpish" monuments which obstruct the architecture, which have no historical reason for being where they are, which might be much more fittingly placed in other parts of the Abbey. On these, so far as friends and survivors will permit, I would have no mercy. But still, even in these cases, and much more in others, I shall always have before my eyes the salutary terror of the projected misdeed of Zachary Pearce.

4. Lastly, the same mixture of mortification and satisfaction which is impressed upon us as we see, in the monuments, the proof of the fallibility of artistic judgment, is impressed upon us in a deeper sense as we read in the history of their graves, or their epitaphs, a like fallibility of moral and literary judgment.

In this way the obscure poets and warriors who have attained the places which we now so bitterly grudge them, teach us a lesson never to be despised. They tell us the works or the deeds in which our fathers delighted; they remind us that the tombs and the graves which now so absorb our minds may in like manner cease to attract our posterity; they put forward their successors to plead for their perpetuation—at least in the one place where alone, perhaps, a hundred years hence neither will be remembered. And if a mournful feeling is left upon our minds by the thought that so many celebrities, great in their day, have been wholly forgotten, yet here and there the monuments contain the more reassuring record, that there are glories which increase instead of diminishing as time rolls on, and that there are judgments in art and in literature, as well as in character, which never will be reversed.

As in Henry VII.'s chapel, the eye rests with peculiar interest on Lord Dundonald's banner, fifty years ago torn from its place, and kicked ignominiously down the flight of steps, yet within our own time, on the day of the old sailor's funeral, reinstated by the herald at the gracious order of the Sovereign—so the like reparation is constantly working on a larger scale elsewhere.

The inscription on Spenser's tomb shows that even then the time had not arrived when the true Prince of Poets was acknowledged in his rightful supremacy; yet he came at last, and the statue of Shakespeare, better late than never, became the centre of a new interest in Poets' Corner, which can never pass away from it. Camden's monument, defaced by some " base villain " in the civil wars, was restored as we now see it by the University of Oxford—that same University from which in his earlier struggles he had vainly sought a Fellowship or a Degree,—one of the many instances of generous repentance by which Oxford has repaid her shortcomings to her eminent sons. The slow growth of Milton's fame is yet more clearly marked. Not only were his remains laid unregarded by the great and learned in their obscure grave, at St. Giles's, Cripplegate, whilst Cowley, a few years before, had been conveyed to his resting-place in Poets' Corner with all the honours that the rank and wit of London could furnish,—but when the tablet of John Philipps, the author of 'The Splendid Shilling,' was erected in the Abbey, containing two lines in which he was described in the epitaph as *uni Miltono secundus*, "second to Milton alone," the then Dean of Westminster, Bishop Sprat, insisted on their erasure, not because of their absurd exaggeration, but because his royalist prejudices could not bear that the name of the regicide Milton should appear anywhere within the walls of the Abbey. But Sprat was succeeded by Atterbury, and Atterbury, even if he did not write the inscription on Phillips, was one of the first profound admirers of 'Paradise Lost.' When the Westminster scholars came to visit him in the Tower, before his exile, to bid him farewell, he could find no words so appropriate as those from his beloved poet:—

"The world was all before him where to choose
His place of rest, and Providence his guide."

He at once admitted the obnoxious comparison. Another few years, and "such was the change of public opinion," said Dr. Gregory to Dr. Johnson, "that I have seen erected within the church a bust of that man whose name I once knew considered a pollution of its walls." And yet a few years pass again, and when Gray's monument was erected, it was not to Chaucer or even to Shakespeare, but to Milton, that the refined and courtly Muse is pointing, with words which celebrate the glory of Milton even more than the glory of Gray. Who would willingly destroy any link in that chain in the success of the triumph of truth and justice which of itself hallows the place which has witnessed it? in the gradual, yet certain reward which so well befitted the poet who, though "fallen on evil days, 'bated no jot of heart and life, but still bore up, and steered right onward?"

I finish this brief sketch. You remember the scholar who was ridiculed because he brought a brick as a specimen of a house. I have been doing something of the same kind. I have brought you not the Abbey itself, but only a few stones. My defence is, that if ever there were sermons in stones, or stones which cry out, they are the gravestones and tombstones of Westminster Abbey.

[A. P. S.]

ANNUAL MEETING,

Tuesday, May 1, 1866.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

The Annual Report of the Committee of Visitors for the year 1865 was read and adopted.

The Books and Pamphlets presented in 1865 amounted to 105 volumes, making, with those purchased by the Managers, a total of 390 volumes added to the Library in the Year.

Fifty-seven new Members were elected in 1865.

Sixty-six Lectures and Eighteen Evening Discourses were delivered during the year 1865.

Thanks were voted to the President, Treasurer, and Secretary, to the Committees of Managers and Visitors, and to Professor Faraday, and the other Professors, for their services to the Institution during the past year.

The following Gentlemen were unanimously elected as Officers for the ensuing year:—

PRESIDENT—Sir Henry Holland, Bart. M.D. D.C.L. F.R.S.
TREASURER—William Spottiswoode, Esq. M.A. F.R.S.
SECRETARY—Henry Bence Jones, M.A. M.D. F.R.S.

MANAGERS.

Warren De la Rue, Esq. Ph.D. F.R.S.
Sir George Everest, C.B. F.R.S.
John Hall Gladstone, Esq. Ph.D. F.R.S.
William Robert Grove, Esq. M.A. Q.C. F.R.S.
Cæsar H. Hawkins, Esq. F.R.S.
Sir John Lubbock, Bart. F.R.S. Pres. Ent. Soc.
John Carrick Moore, Esq. M.A. F.R.S.
William Pole, Esq. M.A. F.R.S.
William Frederick Pollock, Esq. M.A.
Lewis Powell, M.D. F.S.A.
Lt.-Gen. E. Sabine, R.A. D.C.L. LL.D. Pres. R.S.
The Earl Stanhope, D.C.L. F.R.S. Pres. Soc. Antiq.
Joseph William Thrupp, Esq.
Charles Wheatstone, Esq. D.C.L. F.R.S.
Colonel Philip James Yorke, F.R.S.

VISITORS.

Sir Charles Tilston Bright, M.P.	Thomas Hyde Hills, Esq.
John Charles Burgoyne, Esq.	William Edward Kilburn, Esq.
George Frederick Chambers, Esq.	Harry Mackenzie, Esq.
Captain James Drew.	Matthew Noble, Esq.
Samuel Gaskell, Esq.	The Lord Overstone, M.A.
Henry Harwood Harwood, Esq.	Thomas Harrington Tuke, M.D.
Thomas Williams Helps, Esq. M.A.	Henry Twining, Esq.
Sir Thomas Henry.	

WEEKLY EVENING MEETING,

Friday, May 4, 1866.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

Professor F. A. ABEL, F.R.S. V.P.C.S.
CHEMIST TO THE WAR DEPARTMENT.

On Recent Progress in the History of proposed Substitutes for Gunpowder.

THE changes which have been effected in the composition of gunpowder since its first application as a propelling agent, have been limited to small variations in the proportions of its constituents. But the modifications which have from time to time been introduced into the details of its manufacture, *e. g.* the preparation of the ingredients, their incorporation, and the conversion of the mixture into compact masses (grains, &c.) of different size and density, have been sufficiently important and successful to secure the fulfilment by gunpowder, in a more or less efficient manner, of the very various requirements of military science and of different branches of industry.

The characteristics of gunpowder, as an explosive material of permanent character, the action of which is susceptible of great modification, are mainly ascribable to the peculiar properties of the oxidizing agent, saltpetre. Frequent attempts have been made to replace this constituent of gunpowder by other nitrates (such as those of sodium, lead, and barium); but, although materials suitable for blasting operations have been thus prepared (such as soda-gunpowder, and barytic powder, or *poudre saxifragine*), all mixtures of this class, hitherto produced, have exhibited important defects, when compared with gunpowder manufactured for propelling purposes.

The well-known oxidizing agent, chlorate of potash, which differs from saltpetre only in containing chlorine in the place of nitrogen, is far more energetic in its action upon oxidizable bodies than any of the nitrates. Thus, a mixture of chlorate of potash with charcoal alone, deflagrates as violently as gunpowder, and is far more readily inflamed by percussion than the latter; while a mixture analogous to gunpowder, containing chlorate of potash in place of saltpetre, detonates violently when struck with moderate force, and acts far too destructively, on account of the rapidity of its explosion, to admit of its safe employment in fire-arms.

Many years ago, a mixture known as German or white gunpowder, and consisting of chlorate of potash, ferrocyanide of potassium, and sugar, was proposed and tried without success as a substitute for gunpowder; and since then many preparations of similar character have been suggested for employment either as blasting and mining agents, or for use in shells, or even for all the purposes to which gunpowder is applied. The most promising of these, claimed as discoveries by Mr. Horsley and Dr. Ehrhardt, are mixtures of chlorate of potash with substances of permanent character and readily obtained, containing both carbon and hydrogen; such as tannic and gallic acids, and some kinds of resins. These mixtures are much less violently detonating than most of the explosive mixtures containing chlorate of potash, while, if well prepared, they are decidedly more powerful, as explosives, than gunpowder. For blasting purposes, some of these mixtures probably possess decided advantages over ordinary blasting powder, and possibly they may also be susceptible of employment for sporting purposes; but they are not applicable to fire-arms used for war-purposes, because, in order to ensure the requisite uniformity of action, the ingredients must be submitted to proper processes of incorporation, &c., such as are applied to the manufacture of gunpowder; and this treatment would render the mixtures far more violent, and consequently destructive in their action upon fire-arms, than if used in the form of crude mixtures.

A comparatively very safe application of chlorate of potash to the production of a substitute for gunpowder was made about six years ago by a German chemical manufacturer, M. Hochstädter. Unsized (blotting) paper was thoroughly soaked in, and coated with, a thin paste consisting of chlorate of potash, finely-divided charcoal, a small quantity of sulphide of antimony, and a little starch, gum, or some similar binding material, water being used as the solvent and mixing agent. The paper was rolled up very compactly and dried in that form. In this manner, very firm rolls of an explosive material are obtained, which burns with considerable violence in open air, and the propelling effect of which, in small arms, has occasionally been found greater than that of a corresponding charge of rifle powder. Moreover, the material, if submitted in small portions to violent percussion, exhibits but little tendency to detonation. But as no reliance can be placed on a sufficient uniformity of action, in a fire-arm, of these explosive rolls, this alone sufficed to prevent their competing with powder. The same description of explosive preparation, differing only from that of M. Hochstädter in a trifling modification of its composition, which is certainly not likely to lead to its greater success, has recently been brought forward in this country by M. Reichen and Mr. Melland.

One or two other much cruder explosive preparations, containing chlorate of potash, alone or in conjunction with saltpetre, have met with some application to blasting purposes. One of these consisted of spent tan, in small fragments, which was saturated with the oxidizing agent, and afterwards dusted over with sulphur. When flame or a red-hot iron is applied to this preparation, it deflagrates very slowly and imperfectly; but when employed in blast-holes, where it is confined within a small space, it develops sufficient explosive force to do good work. In addition to comparative cheapness, the great advantage of safety was claimed for this material by its inventor, a claim which was substantiated by the partial destruction by fire, on two occasions, of a manufactory of the substance near Plymouth, without the occurrence of an explosion.

The accidental explosions of gunpowder which are occasionally heard of, occur, in most instances, at the manufactories, and in the course of some operation (especially that of incorporation) to which the explosive mixture is submitted. The only means of guarding against, or reducing as much as possible, the liability to the occurrence of these accidents, consist in the strictest attention to the precautionary measures and regulations, which experience has proved to be essential to safety, and which, in spite of the strictest supervision, are unquestionably sometimes overlooked or imperfectly carried out by workmen. Explosions of gunpowder, generally of a serious character, do occur, however, though very rarely, during the transport of the material, or in the magazines where it is stored. The great explosion of a gunpowder magazine at Erith in September, 1864, specially directed the attention of government and the public generally, to the necessity of adopting measures for reducing, as much as possible, the risk of occurrence of such disastrous accidents. Hence, much interest has recently been excited by a well-known method of rendering gunpowder less dangerous in its character, which has been brought prominently before the public by Mr. Gale, and which consists of diluting powder, or separating its grains from each other, by means of a finely powdered non-explosive substance. Attempts have several times been made in past years, to apply to practical purposes the obvious fact, of which nobody acquainted with the nature of gunpowder could be ignorant, that, by interposing between the grains of powder a sufficient quantity of a finely divided material, which offers great resistance to the transmission of heat, the ignition of separate grains of the entire mass may be accomplished without risk of inflaming contiguous grains. In 1835, Piobert made a series of experiments with the view to apply this fact practically, to reduce the explosiveness of gunpowder, and similar experiments of an extensive character were carried on by a

Russian chemist, Fadéiff, between 1841 and 1844. These experimenters found that the object in view might be attained by diluting gunpowder with any one of its components; they also employed very fine sand (a substance closely allied in its physical characters to the powdered glass, which Mr. Gale now proposes to use); but the preference appears to have been given to a particular form of carbon. It was not attempted altogether to prevent the burning of a mass of gunpowder, when a spark or flame reached any portion, but to reduce the rapidity of combustion so greatly as to prevent the occurrence of a violent explosion. No more than this is accomplished by the employment of powdered glass in the proportions directed by Mr. Gale. Indeed, as the quantity of diluent required to give to different kinds of gunpowder the character of equally slow-burning materials, increases with the explosiveness of the particular powder and with the size of its grain, the proportion of powdered glass with which the gunpowder employed in rifled cannon would have to be mixed to render it only slow-burning, would be about double the quantity required for almost altogether preventing the ignition of fine-grain powder, or of the comparatively weak blasting powder with which Mr. Gale's public experiments appear generally to have been instituted. Although a sufficient dilution of gunpowder may secure such comparative safety to the neighbourhoods of large magazines, or to the crews of merchant-vessels in which gunpowder (for blasting purposes, &c.) is transported, as to compensate fully for the inconvenience attending the great increase of volume of the powder, there is no doubt that such a treatment of gunpowder actually issued for military and naval service would be attended by more than one serious obstacle; such as, the tendency of the powder, unless very largely diluted, to separate from the glass, during transport by land or sea, to so considerable an extent as very greatly to diminish the degree of security originally aimed at; the very great addition which would have to be made to the arrangements for carrying the necessary ammunition, in active service; the necessity for introducing, in the field or on board ship, the operations of separating the powder from the glass and transferring it to cartridges and shells (which, whatever sifting and other arrangements were adopted, would be time-taking and very dangerous), instead of preserving the ammunition ready for immediate use; and, above all, the incalculable mischief which would inevitably result from the establishment, in the minds of the soldier and sailor, of an erroneous feeling of security, in dealing with gunpowder, which, however harmless it may, for a time, be rendered, must finally be handled by the men in its explosive form. The extremely rare occurrence of accidents with gunpowder, on board ship or in active land-service, is mainly due to the strictest enforcement of precautionary regulations, some of which may appear at first sight exaggerated or almost absurd, but which combine to maintain a consciousness of danger and a consequent vigilance indispensable to safety.

One of the most remarkable materials recently employed to replace gunpowder as a destructive agent, is nitro-glycerine. This substance was discovered by *Sobrero*, in 1847, and is produced by adding glycerine in successive small quantities to a mixture of one volume of nitric acid of sp. gr. 1·43, and two volumes of sulphuric acid of sp. gr. 1·83. The acid is cooled artificially during the addition of glycerine, and the mixture is afterwards poured into water, when an amber-coloured oily fluid separates, which is insoluble in water, and possesses no odour, but has a sweet, pungent flavour, and is very poisonous, a minute quantity placed upon the tongue producing violent headache, which lasts for several hours.

The liquid has a specific gravity of 1·6, and solidifies at about 5° C. (40° F.); if flame is applied, nitro-glycerine simply burns; and if placed upon paper or metal, and held over a source of heat, it explodes feebly after a short time, burning with a smoky flame. If paper moistened with it be sharply struck, a somewhat violent detonation is produced. Alfred Nobel, a Swedish engineer, was the first to attempt the application of nitro-glycerine as an explosive agent, in 1864.

Some experiments were, in the first instance, made with gunpowder, the grains of which had been saturated with nitro-glycerine. This powder burnt much as usual, but with a brighter flame, in open air. When confined in shells or blast-holes, greater effects were, however, produced with it than with ordinary gunpowder; its destructive action is described as having been from three to six times greater than that of powder. The liquid could not be employed as a blasting agent in the ordinary manner, as the application of flame to it from a common fuze would not cause it to explode. But Mr. Nobel has succeeded, by employing a special description of fuze, in applying the liquid alone as a very powerful destructive agent. The charge of nitro-glycerine having been introduced, in a suitable case, into the blast-hole, a fuze, to the extremity of which is attached a small charge of gunpowder, is fixed immediately over the liquid. The concussion produced by the exploding powder, upon ignition of the fuze, effects the explosion of the nitro-glycerine.

The destructive action of this material is estimated, by those who have made experiments in Sweden and Germany, as about ten times that of an equal weight of gunpowder. Therefore, although its cost is about seven times that of blasting-powder, its use is stated to be attended with great economy, more especially in hard rocks, a considerable saving being effected by its means in the labour of the miners, and in the time occupied in performing a given amount of work, as much fewer and smaller blast-holes are required than when gunpowder is employed. The material appears to have recently received considerable application in some parts of Germany and in Sweden; but, in England, its employment has been confined to one set of experiments instituted in Cornwall last summer, upon which occasion a wrought-iron block, weighing about three hundredweight, was rent into fragments by the explosion of a charge of less than one ounce of nitro-glycerine placed in a central cavity.

Nitro-glycerine appears, therefore, to possess very important advantages over gunpowder as a blasting and destructive agent, but the attempts to introduce it as a substitute for gunpowder have already been attended by most disastrous results, ascribable in part to some of its properties and the evident instability of the commercial product, but principally to the thoughtlessness of those interested in its application, who appear to have been induced, either by undue confidence in its permanence and comparative safety, or from less excusable motives, to leave the masters of ships, or others who had to deal with the transport of the material, in ignorance of its dangerous character.

The precise causes of the fearful explosions of nitro-glycerine which occurred at Aspinwall and San Francisco will, in all probability, never be ascertained; but they are likely to have been due, at any rate indirectly, to the spontaneous decomposition of the substance, induced or accelerated by the elevated temperature of the atmosphere in those parts of the ships where it was stored. Instances are on record in which the violent rupture of closed vessels containing commercial nitro-glycerine has been occasioned by the accumulation of gases generated by its gradual decomposition; and it is at any rate not improbable that a similar result, favoured by the warmth of the atmosphere, and eventually determined by some accidental agitation of the contents of the package of nitro-glycerine, was the cause of those lamentable accidents. The great difficulties attending the purification of nitro-glycerine upon a practical scale, and the uncertainty, as regards stability, of the material, even when purified (leaving out of consideration its very poisonous character and its extreme sensitiveness to explosion by percussion when in the solid form), appear to present insurmountable obstacles to its safe application as a substitute for gunpowder.

The conversion of purified lignin or wood fibre into an explosive substance of the same nature as gun-cotton, was accomplished by chemists soon after Schönbein's discovery of gun-cotton was made known. Finely divided wood, or sawdust, may, by treatment with suitable agents, be to a very considerable extent purified of substances foreign to cellulose; and, if then submitted to careful digestion in a mixture of the strongest nitric and sulphuric acids, and properly purified, it furnishes a highly explosive material similar to the most explosive gun-cotton, and possessed apparently of considerable stability. Captain Schultze, a Prussian artillery officer, who was entrusted by his government a few years ago with the investigation of gun-cotton, appears to have come to the conclusion that finely-divided wood offered greater prospect of conversion into a controllable explosive agent than cotton wool. The ultimate result of his investigations has been the production of a "gun-sawdust," the explosive properties of which depend in great measure upon its impregnation with a considerable proportion of an oxidizing agent, either saltpetre or a mixture of that salt and nitrate of barium. The wood, having been reduced to a tolerably uniform state of division, is submitted by Captain Schultze to purifying processes, for the separation of resinous and other substances from the lignin, and the product is converted by digestion in a mixture of sulphuric and nitric acids into a very feebly explosive material, which leaves a considerable carbonaceous residue when burnt. This product after purification is impregnated with a sufficient proportion of nitrates to give it rapidly explosive power, the oxidation of the carbon being now almost complete. The objects which appear to be aimed at by Captain Schultze in following this method of manufacturing a wood-gunpowder, are, the production of a more gradually explosive material than is obtained by the most perfect action of nitric acid upon wood-fibre, and the possibility of preserving the material in a slightly explosive and therefore comparatively harmless form, until it is required for use, when it may be soon rendered powerfully explosive by impregnation with the nitrates. It is asserted that this powder is considerably more powerful than gunpowder as a mining agent; and that, by its employment in mines, the operators are enabled to return to work sooner than when gunpowder is used, because there is little or no smoke produced by its explosion. The latter is an undoubted advantage which Schultze's powder shares with gun-cotton. Advantages are also claimed for this material when employed in fire-arms, and it is possible that, when applied to sporting purposes, it may compete successfully with gunpowder in this direction also; but its behaviour as an explosive, and the peculiarities of its structure, afford little promise of its advantageous employment in arms for military and naval purposes.

Important progress has been made in the history and the practical application of gun-cotton since its study was resumed in this country about three years ago. Very considerable quantities of the material have been manufactured at the works of Messrs. Prentice at Stowmarket, and at the Government Gunpowder Works at Waltham Abbey; its application to mining and artillery purposes, and to small arms, has been, and is still the subject of systematic experiment, conducted by the Government Committee on Gun-cotton; its employment as a blasting agent is steadily increasing in several important English mining districts; and considerable, though not uniform, success has already attended the employment of gun-cotton cartridges for sporting purposes.

The system of manufacture of gun-cotton, as perfected by Baron Von Lenk, has undergone but trifling modifications in its employment in this country. It has been made the subject of careful investigation by Mr. Abel, and the results furnished by many experimental manufacturing operations, and an examination of the products, have shown that the process of converting cotton into the most explosive form of pyroxilin or gun-cotton, and of purifying the material, have been so greatly perfected by v. Lenk as to render a strict adherence to his simple and precise instructions alone necessary to ensure the preparation of very uniform products, which exhibit in their composition a very much closer approximation to purity than those obtained in the earlier days of the history of gun-cotton.

Although the conclusions arrived at by the many chemists who investigated the composition of gun-cotton, soon after Schönbein's discovery, varied very considerably, the constitution has been very generally regarded as definitely established by the researches of Hadow, published in 1854. According to that chemist, the most explosive gun-cotton has the composition expressed by the formula $C_6 H_7 N_3 O_{11}$ (which was first assigned to the substance by W. Crum, in 1847), and may be regarded as cellulose, in which three atoms of hydrogen are replaced by three molecules of peroxide of nitrogen. The name *trinitro-cellulose* has therefore been assigned to gun-cotton, its constitution being expressed by the formula $C_6 \left\{ \begin{matrix} H_7 \\ 3\,N\,O_2 \end{matrix} \right\} O_5$. Hadow's conclusions have since been confirmed by other chemists, more especially by Redtenbacher, Schrötter, and Schneider, who have analyzed specimens of gun-cotton prepared under Von Lenk's directions. But a Report upon the Austrian Gun-cotton was published in 1864 by Pelouze and Maury, in which the formula $C_{24} H_{36} O_{18}, 5\,N_2 O_5$ is assigned to the product of v. Lenk's process; the conclusions of those chemists being founded partly upon some analytical results, and partly upon the increase of weight which they found cotton to sustain, when submitted to treatment with the mixed acids. They found the greatest increase in weight to be 78 per cent.—a number slightly in excess of that which would correspond to the requirements of the formula which they adopt.

An experimental inquiry into the composition of gun-cotton, as obtained by v. Lenk's process, has been instituted by Mr. Abel; and the very numerous analytical and synthetical results which he has obtained, confirm the correctness of the formula assigned by Crum and Hadow to the most explosive gun-cotton, and demonstrate satisfactorily that the products obtained by following strictly the instructions given by v. Lenk, are invariably trinitro-cellulose, in a condition as nearly approaching purity as a manufacturing operation can be expected to furnish.

The most explosive gun-cotton is perfectly insoluble in mixtures of ether and alcohol; but by varying the proportions and strength of the acids employed for the conversion of cotton, products of less explosive character are obtained, which are more or less freely soluble in ether and alcohol (furnishing the well-known material *collodion*). If, therefore, in manufacturing gun-cotton, the conditions essential to the production of insoluble pyroxilin are not strictly fulfilled, the uniformity of the product will suffer.

The ordinary products of manufacture are never altogether free from soluble gun-cotton; but the proportion present is small and very uniform, amounting to about 1·5 per cent. They contain, besides, a small quantity (about 0·5 per cent.) of matter soluble in alcohol alone, and possessed of acid characters, which is evidently produced by the action of nitric acid upon such small quantities of resinous or other matters foreign to pure cellulose, as are not completely removed from the cotton fibre by the purification which it receives.

There appears good reason to believe that this impurity in gun-cotton is of comparatively unstable character, and that the great proneness to spontaneous decomposition which has been observed by Pelouze and Maury, De Luca, and others, in some specimens of gun-cotton, is to be ascribed in great measure to the existence in those specimens of comparatively large proportions of those unstable bye-products.

One hundred parts of carefully-purified cotton wool have been found by Mr. Abel to furnish from 181·8 to 182·5 parts of gun-cotton. The increase which *perfectly pure cellulose* should sustain by absolutely complete conversion into a substance of the formula $C_6H_7N_3O_{11}$ *(trinitro-cellulose)* is 83·3: the above results are therefore strong confirmations of the correctness of this generally-accepted view of the composition of gun-cotton. In carrying out the actual manufacturing process, as prescribed by v. Lenk, somewhat lower results are obtained, because of impurities existing in the cotton employed, and of loss of product during its purification.

Very extensive experiments are in progress at Woolwich, with the view of examining fully into the extent of liability to change of gun-cotton when preserved in store, or exposed for prolonged periods to light and to degrees of heat ranging between the ordinary atmospheric temperatures and that of boiling water. The results hitherto arrived at, though they have shown that, under severe conditions, gun-cotton is liable to decompose, have not confirmed the conclusions arrived at by the French chemists, with regard to the great instability of the material. Thus De Luca states that, all specimens exposed by him to sunlight decomposed either on the first day or within a few days. But, at Woolwich, no single instance of such rapid decomposition of gun-cotton, made by the present process, has been noticed. A very gradual and slight development of gas occurs after a time when the substance is exposed to sunlight; but the quantity which has been collected from specimens exposed at Woolwich to direct day- and sunlight for two years and a half, is very small, and the gun-cotton has in all instances preserved its original appearance. Pelouze and Maury state that gun-cotton always decomposes perfectly within a few days, by exposure to temperatures of 55°—60° C. (130°—140 F°.), and they lay great stress upon the explosion of a specimen directly it was introduced into a vessel heated to 47° C. (116°·6 F.). But, at Woolwich, a specimen of ordinary product which has been exposed now for twelve months to 65° C. (150° F.), has evolved only a small quantity of gas, and retains its original appearance perfectly. Several specimens, after having been exposed for some hours to a temperature of 90° C. (194° F.), during which period some nitrous vapours were in all instances evolved, have since been exposed to light in closed vessels for about twenty months, and still retain their original appearance and explosive characters. Several large ammunition-cases, closely packed with gun-cotton, have been preserved for six months in a chamber, the temperature of which was maintained for three months at 49° C. (120° F.), and afterwards at 54°—55° C. (130° F.), arrangements having been made for periodically registering the temperature within the boxes, which were kept closed. In no instance has the latter temperature risen to an extent to indicate serious chemical change, *i. e.* it has always been below the temperature of the air in the chamber. These few examples of results already obtained are given to show that the behaviour of gun-cotton manufactured in England by v. Lenk's process does not, as yet, at all justify the condemnation which the material has recently received in France.

One most important point in connection with the preservation of gun-cotton appears to have been lost sight of by the French experimenters. The material may be most perfectly preserved, apparently for any period, either by immersion in water, or, still more simply, by being impregnated with just sufficient moisture to render it perfectly uninflammable. In this condition, gun-cotton is much safer than gunpowder can be rendered, even by mixture with very large proportions of incombustible materials. It may be transported with quite as much safety as the unconverted cotton ; indeed, it appears to be very much less prone to gradual decay, if preserved for very long periods in a damp condition, than cotton or other vegetable substances. Many specimens of gun-cotton, preserved for several months in a very damp chamber, together with paper, cotton fabrics, and wood, retained their strength of fibre and all their original properties, and had no signs even of mildew upon them, while the paper fabrics in immediate contact with them had completely rotted away, and the wood was covered with fungi.

Considerable progress has been made in the manipulation of gun-cotton, with the object of modifying its explosive action. The rapidity with which gun-cotton burns *in open air* admits of ready and very considerable variation by applying the simple expedients of winding, twisting, or plaiting gun-cotton yarn of different sizes. But, although a mass of gun-cotton may be made to burn in a comparatively gradual manner by being very tightly wound, a charge of the material in that form acts quite as destructively when exploded in the bore of a gun as an equal charge consisting of the yarn wound very loosely, because the pressure of gas established by the first ignition of the charge renders the compact packing of the gun-cotton powerless to resist the instantaneous penetration of flame between the separate layers of the material. The assertion that a power had been acquired of controlling the explosive action of gun-cotton in a fire-arm by simply varying the compactness with which the material was twisted or wound, has, therefore, proved quite erroneous. There are, however, two methods of reducing the rapidity of explosion of gun-cotton, which are much more likely to furnish successful results. The one consists in diluting the material by its admixture either with a less explosive variety of gun-cotton or with some inexplosive substance, such, for instance, as the cotton in its original form. The latter mode of dilution has recently been applied by Messrs. Prentice to the construction of cartridges for sporting purposes, and they describe the results already arrived at as very promising. The second method of controlling the explosion of gun-cotton consists in consolidating the material by pressure into compact homogeneous masses, and in confining the first ignition of such compressed gun-cotton in the bore of the gun, to certain surfaces. The gun-cotton fibre in the form of yarn or plait may be compressed into very compact masses by being rammed into strong cylinders of pasteboard or other suitable material; but much more perfectly homogeneous and solid masses are produced, independently of cylinders or other cases, by a method which Mr. Abel has recently elaborated, and which consists in reducing the gun-cotton fibre to a fine state of division or pulp, as in the process of paper-making, and in converting this pulp by pressure into solid masses of any suitable form or density.

This method of operating affords also special facilities for combining both methods, dilution and compression, of reducing the explosive violence of gun-cotton. The material is, in fact, operated upon by this system, in a manner exactly corresponding to the processes by which the explosive action of gunpowder is regulated to so remarkable an extent. Some results, which are admitted by the most sceptical as encouraging, have already been arrived at, in the systematic course of experiments which are in progress, with the object of applying the methods of regulation, pointed out, to the reduction of gun-cotton to a safe form for artillery purposes. Its arrangement in a form suitable for small arms is a much less difficult problem, which may be considered as approaching a perfect solution. For employment in shells and for military mines, both land and submarine, the compressed or solid form of gun-cotton presents special advantages, on account of the great compactness which may be imparted to it; a given weight arranged so as to ignite instantaneously under pressure (*i.e.* in strong vessels), may be made to occupy the same space as an equal weight of gunpowder, whereas the forms of gun-cotton hitherto applied to these purposes occupy about three times the space of gunpowder.

Beautiful pyrotechnic effects may be readily produced by means of gun-cotton, though the absence of smoke, which, in some of its applidations (especially in mines), would constitute an important advantage, detracts from some of the effects which may be obtained with pyrotechnic compositions. On the other hand, gun-cotton fireworks may be displayed in-doors without inconvenience.

There appears at present no reason to doubt that the application of gun-cotton with great advantage to at least some of the more important purposes for which gunpowder is used, will, ere long, be fully established, and that this interesting explosive agent is destined to occupy a permanent and prominent position among the most important products of chemical industry.

[F. A. A.]

GENERAL MONTHLY MEETING,

Monday, May 7, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

The following Vice-Presidents were nominated for the ensuing year:—

The Earl Stanhope, D.C.L. F.R.S.
Lieut.-General Sabine, R.A. Pres. R.S.
W. Robert Grove, Esq. Q.C. F.R.S.
William Spottiswoode, Esq. M.A. F.R.S. *the Treasurer.*

Samuel Osborne Habershon, M.D.
John Hogg, M.D.

were *elected* Members of the Royal Institution.

The following Professors were re-elected:—

John Tyndall, Esq. LL.D. F.R.S. as Professor of Natural Philosophy.
Edward Frankland, Esq. Ph. D. F.R.S. as Professor of Chemistry.

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same, viz.:—

FROM

Actuaries, Institute of—Journal, No. 63. 8vo. 1866.
Agricultural Society of England, Royal—Journal. New Series. No. 3. 8vo. 1866.
Asiatic Society of Bengal—Journal, No. 130. 8vo. 1865.
Astronomical Society, Royal—Monthly Notices, 1865-6. No. 5. 8vo.
British Architects' Institute, Royal—Sessional Papers, 1865-6. Part II. No. 4. 4to.
Chambers, George F. Esq. M.R.I. (*the Author*)—The Church and State Handybook. (K 92) 8vo. 1866.
Chemical Society—Journal for May, 1866. 8vo.
Clarendon, The Earl of, K.G. &c.—Pitture Murali a fresco e Suppellettili Etrusche scoperte in una necropoli presso Orvieto nel 1863 da D. Golini: publicata da G. Conestabile. 4to. Firenze. 1865.
Editors—Artizan for April, 1866. 4to.
  Athenæum for April, 1866. 4to.
  British Journal of Photography for April, 1866. 4to.
  Chemical News for April, 1866. 4to.
  Engineer for April, 1866. fol.
  Horological Journal for April, 1866. 8vo.
  Journal of Gas-Lighting for April, 1866. 4to.
  Mechanics' Magazine for April, 1866. 8vo.
  Pharmaceutical Journal for April, 1866.
  Practical Mechanics' Journal for April, 1866. 4to.
Hardwicke, Robert, Esq. (*the Publisher*)—Skin Diseases. By W. Tilbury Fox. 2 vols. 8vo. 1863-4.
Linnean Society—Journal and Proceedings: Zoology: No. 33. 8vo. 1866.

Medico-Chirurgical Society, Royal—Proceedings, Vol. V. No. 4. 8vo. 1866.
Meteorological Society—Proceedings, No. 21. 8vo. 1866.
Philadelphia Academy of Natural Sciences—Proceedings. 8vo. 1865.
Photographic Society—Journal, No. 168. 8vo. 1866.
Squire, Peter, Esq. F.L.S. M.R.I. (the Author)—Companion to the British Pharmacopœia. 3rd edition. 8vo. 1866.
Statistical Society of London—Journal, Vol. XXIX. Part 1. 8vo. 1866.

WEEKLY EVENING MEETING,

Friday, May 11, 1866.

Colonel PHILIP JAMES YORKE, F.R.S. in the Chair.

Professor D. T. ANSTED, M.A. F.R.S.

On Mud Volcanoes of the Crimea, and on the relation of these and similar phenomena to deposits of Petroleum.

IN this communication I propose to direct attention to the following subjects, namely:—

First.—Mud volcanoes generally, and especially those of the Crimea and Sicily, as phenomena of subdued volcanic action.

Secondly.—The frequent occurrence of petroleum, naphtha, and other hydro-carbons in the vicinity of mud volcanoes.

Thirdly.—The existence of lignites, coal, or other deposits of vegetable or animal organic matter near mud volcanoes.

Fourthly.—The geological relation probably existing between mud volcanoes, recognized lines of volcanic energy, main lines of elevation affecting great tracts of land, and the metamorphoses that have produced the hydro-carbons in the form of petroleum, naphtha, bitumen, and bituminous shales.

I. MUD VOLCANOES.

The phenomena of mud volcanoes are illustrated on a grand scale in the eastern part of the Crimea, near Kertch, and on the adjacent peninsula of Taman. The eastern shore of the Cimmerian Bosphorus is nearly level, but in certain places presents a multitude of hillocks and some considerable hills. These hills are due to eruptions of mud. Some are large and lofty, and do not now erupt mud. Others are also of large dimensions, but are continually or occasionally active. I visited the Crimea in the course of last summer, and although for some months previously none of the older and larger mud volcanoes had broken out afresh, and no new ones had appeared, it was not difficult from the number of examples in different states of activity to make out the principal varieties of appearance. Before describing them, however, I think it will be better to give a brief account of an eruption of the same nature that occurred in Sicily during my stay in the island. I was on that occasion fortunate enough to be able to visit a mud volcano from its commencement, and thus, combining the observations in Sicily and the Crimea, I have been able to judge of and describe from my own observation the whole history of one of these curious phenomena. The Sicilian eruption commenced seven days only before the commencement of the eruption in the island of Santorin. It should be borne in mind that the eruption of Etna of last year was accompanied by subterranean action in the Ægean sea, both near the extremity of the Morea and also in Santorin itself; and although the distance is five hundred miles, a subterranean communication must be considered proved.

At Paternó, close to the south-western extremity of the Etna lavas, a mud eruption took place on the 23rd of last January, in a flat plain below the steep hill on which Paternó is built, and not far from the bed of the Simeto. It commenced by the outburst of a strong jet of water, which must have issued through a crevice in underlying lava. The crack is not traceable in the conglomerate and sandy gravel of the surface, except from the indications afforded by the eruptions. The water at first rose about six feet in a strong jet, at boiling temperature, from only one point. Several such jets followed from other places a few yards off, the volume of the first jet diminishing though the total quantity of water erupted was increased. The temperature of the erupted water diminished slowly from the commencement. There was no noise, no flame, and no visible vapour, but much gas bubbling through the water, and some naphtha.

The water issuing was muddy from the commencement, but no stones or lumps of solid matter were erupted. The level of the point of eruption was about 600 feet above the sea, as determined by an aneroid. The water erupted ran off into the Simeto, leaving behind a thin coating of tenacious mud, which covered the ground for some distance.

I visited the spot on the eighth day from the commencement. From the principal jet there then issued a large column of dirty water, with much gas. A considerable quantity of petroleum of dark-green colour floated on the surface of the water, but had not been collected. The temperature of the water was above 110° Fah., but observations were difficult to make and uncertain, owing to the absence of a maximum thermometer. The heat was certainly much greater than was recorded, as the water scalded the hand. The gas bubbles were large, and issued at intervals by puffs, of which forty per minute were counted. The gas was chiefly carbonic acid gas. There were four other considerable jets of warm but not hot water all in a line, and all in the direction of a line joining the original point of eruption with the principal cone of Etna. They were about four yards apart. A multitude of much smaller jets of cold muddy water came out from cracks in the ground at various points within an area of about twenty acres. None of the issuing fluid could be called thick mud, but on exposure to the air and evaporation it left a tenacious paste. About 300 yards beyond, in the direction of the great cone of Etna, there is a remarkable spring of water loaded with carbonic acid gas, rising at a temperature of 64° Fah. Though well known and used this spring does not seem to have been affected by the eruption. Except at Pyrmont, I have never seen water so charged with gas. A short distance beyond this spring is another of subacid water issuing from beneath old lava, at a temperature of 60° Fah.

About a mile from the mud volcano, and in the direction opposite to the springs, are blocks of very tough basaltic lava, on a natural slope. They had apparently fallen from a basaltic cliff above. These blocks, when struck with a hammer, give out a strong bituminous odour, and when a fragment is broken off, innumerable small cavities full of naphtha may be observed on examining the broken surface.

The mud volcanoes of the Crimea and Taman are very numerous, and all within a belt of country nearly parallel with the axis of the Caucasus. It is known that similar phenomena exist near Teflis, halfway between the Black Sea and the Caspian, at Baku, on the western shore of the Caspian, and in islands near the eastern shores of the Caspian. The district I chiefly examined reached about fifty miles from the straits of Kertch, towards the east, and about twenty miles towards the west.

Near Enikale are several distinct cones. Of these some are moderately active, many quite inactive. The date of activity can often be guessed at by the state of the slopes; for the mud as it first issues, and for some time afterwards, is perfectly unfit for vegetation, but after about two years' exposure it begins to acquire properties and materials allowing vegetable growth. By noticing the state of vegetation, I was thus able to make out that many of the hills had been very recently subject to a flow of mud, though quite dry at the time of my visit.

The erupting cones are all of the same general character. The mud is poured out very slowly from the top, and is tenacious and often as thick as treacle. Bubbles of gas accompany the mud. In one case I counted fifteen large bubbles per minute, in another thirty. The temperature of the issuing mud was in one case 56° Fah., in another close by as much as 66° Fah. I measured the length of one coulée of mud, and found it to be about 60 yards from the outlet before it was completely checked. The various cones are accumulated from the material erupted, and in no other way. In the cone I measured I found the fall to be 20 feet, the slope therefore being one in nine. Other cones, and the upper part of all the cones, are much steeper than this.

In all this group a north wind is universally understood to increase the flow of mud, and the quantity of mud issuing varies from month to month and at different seasons. It not unfrequently stops altogether for some time.

A short distance to the west of Enikale is another tract of considerable area completely covered with recently erupted mud. The mud is always of the same kind, blackish when dry, very tenacious, and as it runs exceedingly fine. I observed, however, in each place a number of fragments of clay ironstone, all of small size, and distributed pretty evenly over the mud hills; and this fact I also noticed on all the cones both at Kertch and Taman. I have seen and possess parts of a fragment of lignite erupted from a mud volcano at Sassuolo, near Modena.

Not far from Kertch, towards the south-west, is another and similar mud volcano, and near it a large old cone evidently due to the same cause. Several small mud springs are close by.

On the opposite or eastern side of the straits of Kertch, and within the peninsula of Taman, which is formed by the delta of the Kuban (the largest of the rivers coming from the northern watershed of the Caucasus), there is a very important and extensive group of conical hills of marl and mud, which beyond a doubt are due to the issue of mud under circumstances identical with those just described. They occupy an area of many square miles. The Kuban itself terminates in a wide expanse of mud, covered for the most part with less than a foot of water, and the whole of the peninsula of Taman is an alternation of mud banks above and below the water's edge, with a few narrow channels passable for vessels of small burden. It is only the mud cones that relieve the monotony of the surface.

We owe to Pallas a detailed account of an eruption that took place in this peninsula towards the close of the last century. This eruption resulted in the formation of a large conical hill visible from Kertch, which is about 14 miles distant, and a prominent object to vessels passing through the straits. I visited this cone, though with some difficulty, as no one on the spot knew anything about it, and there is neither a landing place near nor any road leading to it. It is on the opposite side of the creek, on which is the village of Taman. I found it extinct, but with marks of recent eruption of mud on a small scale. The main cone has been much weathered. It consists of clay, with small angular lumps of limestone and small fragments of earthy oxide of iron. There is a depression or crater at the top. The height I estimated at about two hundred and fifty feet, but I could not quite trust my aneroid. It is now called Gorela, a name which merely means a hill. It seems to have been known by other names a few years ago, being called Kakuoba in Col. Jervis's map.

Several miles from this old cone, towards the east, is the village of Aktinisorka, near which I found a remarkable group of mud volcanoes in activity at the time of my visit. There were four of large size, all issuing mud. Another, which had been active in 1863, I found covered with vegetation. These hills were about the same height as that described by Pallas (which is now called Gorela), and form a considerable group. They are called Luvarka. Like the others, their slopes contained numerous fragments of iron oxide. A ridge, some miles long, behind and near the village of Taman, is also entirely formed of erupted mud; but these mud hills are detached from the group just described. Indications of mud volcanoes extend eastwards beneath the Caucasus to the Caspian, and westwards towards and into the Putrid Sea, so that the belt of mud volcano country on the southern slopes of the Caucasus is almost unbroken, and extends across the low flat plains of the south of Russia to a very great distance, being everywhere marked by the same peculiar condition and with similar proofs of communication with the interior of the earth. The distances referred to are roughly as follows:—From the eastern Caspian to Teflis, about 500 miles with various connecting links. From Teflis to Anapa, nearly 400 miles without such links. From Anapa to the Putrid Sea, unquestionably connected by similar phenomena, 200 miles.

Crossing a large part of Eastern Europe we do not again meet with distinct indications of mud volcanoes till we reach North Italy, where there are some well known and remarkable examples at Sassuola and elsewhere, on the northern slopes of the Apennines, in the provinces of Modena and Parma. These have exhibited all the phenomena above described within the last century, and they are also described in classical works. From one of these there have been eruptions of solid matter, and even of lignite, already alluded to. On the other side of the Apennines the boracic springs near Volterra are of the same nature, but true active mud volcanoes have not, I believe, been observed or described till we reach Sicily. There, both on the slopes of Etna and near the southern coast at Girgenti, they recur with the usual characteristics. The latter have often been described.

From the Caspian sea, eastward, at various places on the northern slopes of the Himalayan chain, and so into China, mud volcanoes have been noticed. They appear to exist on a very large scale in Java. They belong also to the volcanic system of the new world, where the Mexican examples are recent and very extensive, the phenomena being nearly the same as those described. The most remarkable and instructive of those that have been less prominently referred to by geological writers are those in Trinidad, others occurring in California, and some in Iceland.

It will be useful to say a few words with regard to some of these before passing on to the next division of the subject. The Trinidad mud volcanoes have been described recently by Mr. G. P. Wall. According to Bunsen, the mud eruptions of Hecla appear to be chiefly dirty water, slightly impregnated with mud, and very hot. In this respect they agree rather with that of Paternó than those of the Crimea. Being nearer the great centre of volcanic heat, the phenomena are less sluggish. The corresponding phenomena in California (in the Colorado district) are near extinct volcanic rocks of the ordinary kind. Here also the heat is intense, and the mud is erupted in jets to the height of several feet, and sometimes even to a hundred feet. Fragments of pumice are scattered over the plain, and the mud runs off in a slimy stream towards a neighbouring salt lake. In other respects the conditions appear identical with those of Asia and Europe, and to connect these with the great geysers and hot muddy springs of Hecla.

On the whole, then, it may be concluded that mud volcanoes represent in a very striking manner the declining stage of volcanic activity under certain conditions which are not by any means universal. There are certainly many volcanic districts where there does not seem anything of the kind; many, where hot water alone or thermal mineral springs are ejected, others where there are special minerals, as borax, in exceptional abundance. True mud of the ordinary kind may be erupted, thin or thick, with or without foreign substances, and at temperatures varying between a heat much exceeding the boiling point of water and the equivalent of the mean annual temperature of the district. The phenomena also, though they vary in details, are on the whole constant in their nature and in the order of their occurrence. The eruption may be described as commencing with heated water and gases, occasionally accompanied by mud, and even considerable fragments of rock. The eruptive force exerted being comparatively small, the result in this respect is also small; but, as in other volcanic districts, the force exhibits itself by forming crevices in the earth, along certain lines of least resistance. In mud volcanoes the steam issuing from the crevices has been condensed into water before it reaches the surface. The erupted water also brings with it such earthy substances as it meets on its way, and thus mud more or less thick issues from the crevice instead of lava. With regard to the carbonic acid and other gases, the thin mud allows of their passage to the surface in bubbles.

II. Petroleum and Bitumen.

In all the mud volcanoes above alluded to, and in all others that have been minutely described by competent observers, it appears that mineral oil (either naphtha or petroleum) either issues with the muddy stream that forms the erupting matter (which is very commonly the case) or comes out in some quantity from springs or wells immediately adjacent. Thus at Baku, and at other points across the Caspian, the quantity of naphtha obtained from springs near the mud volcanoes is enormously great, and has continued to flow from time immemorial. Near Teflis there are important naphtha springs. At Anapa there has recently been obtained a spouting well. In the peninsula of Taman there are abundant indications of petroleum proceeding through tertiary rocks. Near Kertch, in the neighbourhood of all the mud volcanoes alluded to, there are numerous shallow wells dug into tertiary marls, whence a supply of oil has been obtained by the Tatars from time immemorial. The number of such old wells is too great to be estimated. In one instance I noticed a well yielding a considerable quantity of naphtha, sunk within less than a dozen yards from erupting mud, and on the very slope of an extinct cone of mud. In another the water, as it rose with the mud, was covered with a film of naphtha. A smell of naphtha pervades large tracts of country, and, mixing with sulphuretted and perhaps phosphuretted hydrogen, effects the whole atmosphere of the Putrid Sea. In all these cases there is distinct geological evidence that the petroleum springs are connected with crevices usually in clayey and shaly rocks, which are often quite saturated with the oil. Sometimes they pass through limestones, or compact sandstones, and then these rocks are rendered highly bituminous. In the south of Italy there is an issue of mineral oil floating on water at one spot, and not far off is a vast deposit of bitumen nearly pure. The whole length of the Apennines, on the eastern side, exhibits at frequent intervals the most direct proof of the existence of bitumen. Towards the north, and where the mountains change their direction, and range parallel to the main chain of the Alps, there are numerous wells of petroleum and naphtha of remarkable purity rising through the rocks under similar circumstances. In Asia Minor, again, at the Dead Sea, and on the former sites of Sodom and Gomorrah, are similar phenomena, which, indeed, are continued across Greece into the Ionian Islands. Zante has been celebrated since the time of Herodotus for its wells of petroleum, while Egypt and Arabia continue the oil district towards the south. In all these parts of the world there are places where petroleum, either in a fluid, semi-fluid, or recently solidified state, exists within the earth, and in many spots it runs out to the surface like water. Trinidad and the adjoining part of South America afford numerous and magnificent instances of mud volcanoes, accompanied by large issues of naphtha and petroleum in all varieties of condition.

But besides the spots already mentioned, in which petroleum issues in the neighbourhood of mud volcanoes, or in such direct volcanic association that we can at once trace the connecting links, there are others, and those the most remarkable in the world for the actual quantity of mineral oil obtained, where no mud volcanoes are known to be near, and even where there is no volcanic influence of any kind at hand. I allude, of course, to the oil-bearing districts in North America, where the oil rises in quantities proportionate to the magnitude of the coal-fields and to the vast folds of the strata through which it reaches the surface. These indicate geological axes of extreme importance and magnitude; and, although there are no evidences of communication with the interior such as volcanoes offer, there is clear geological proof of the action of upheaving forces on the grandest scale.

Wherever there are deposits of mineral fuel and of large quantities of organic matter accumulated during some past period of the earth's history, there are in the neighbourhood, either oils or bituminous minerals. Bituminous shales, grits, limestones, and even ironstones, so saturated with bitumen that they will yield mineral oils on distillation at a low heat, are met with in most of the coal-fields throughout the world. It does not matter what may be the geological age of the coal, or whether it be coal or lignite. The bituminous mineral also may be of any kind.

If we distinguish between petroleum, in a fluid or thickened state, and bituminous shales, commonly so-called, we shall find that springs of mineral oil rise chiefly in lines parallel to certain great mountain chains.

On the other hand many great deposits of bitumen and bituminized minerals, are less clearly brought into relation with similar causation.

The petroleum springs, so abundant in the Caspian, range along the foot of the Caucasus, and are continued for a long distance in the same direction. They commence again at the foot of the Carpathians, where they abound in Galicia, and are numerous in Wallachia. In both countries the quantity of oil is probably large, and the number of spots whence the mineral has been obtained is, certainly, enormous. We lose sight of them as the Carpathians pass into the Alps, but they recur where the Apennines pass away from the Alps. We find them occasionally on the flanks of the Apennines, but more abundantly in France, where the Alps themselves die away into the plains. They are met with near the outlying coal-fields in the south of France.

But most of all are they abundant and productive in the folds of the great anticlinals in North America.

On the other hand, the richest and most valuable shales and cannel coals are those found in parts of the Scotch, Lancashire, and Flintshire coal-fields, in neither case far from basaltic eruptions of ancient or modern date, but very far from the great mountain chains and axes of main elevation. Other bituminous shales of value occur in other coal-fields, and with or near lignites in many districts, and of all geological ages. Throughout the great plains of Europe there are cases in point which I need not here quote. Others have been described, some very recently, in Australia. Many are known in Asia and America, but most of them are less important. There is hardly a coal-field, and not many beds of available lignite, without bituminous rocks adjoining or enclosing them. This relation, so universal and so widely spread, cannot be without some distinct meaning in the history of the earth.

It would seem clear that the hydro-carbons locked up among the strata of the earth, and now only beginning to be released and rendered useful, are parts of the great history of metamorphosis and change that has affected every deposit during all time.

III. ORGANIC DEPOSITS NEAR MUD VOLCANOES.

The various minerals that, under the names of petroleum, naphtha, bitumen, cannel-coal, and bituminous shales, are now so much sought after, and most of them so valuable, have, in all probability, obtained their carbon from organic deposits. Their hydrogen may have been derived partly from the excess of that gas present in all organic matter, partly from the decomposition of water; and their history, in either case, is connected with that great and systematic metamorphosis induced and constantly in progress in the interior of the earth. A slow distillation of coal or lignite, effected with comparatively little heat, and enduring for a long time under favourable circumstances, must be accepted as the general explanation of the various phenomena. Where, as in Trinidad, the quantity of bitumen is so large, and the production so recent that we can see the process as it has gone on and its actual that the petroleum springs are connected with crevices usually in clayey and shaly rocks, which are often quite saturated with the oil. Sometimes they pass through limestones, or compact sandstones, and then these rocks are rendered highly bituminous. In the south of Italy there is an issue of mineral oil floating on water at one spot, and not far off is a vast deposit of bitumen nearly pure. The whole length of the Apennines, on the eastern side, exhibits at frequent intervals the most direct proof of the existence of bitumen. Towards the north, and where the mountains change their direction, and range parallel to the main chain of the Alps, there are numerous wells of petroleum and naphtha of remarkable purity rising through the rocks under similar circumstances, In Asia Minor, again, at the Dead Sea, and on the former sites of Sodom and Gomorrah, are similar phenomena, which, indeed, are continued across Greece into the Ionian Islands. Zante has been celebrated since the time of Herodotus for its wells of petroleum, while Egypt and Arabia continue the oil district towards the south. In all these parts of the world there are places where petroleum, either in a fluid, semi-fluid, or recently solidified state, exists within the earth, and in many spots it runs out to the surface like water. Trinidad and the adjoining part of South America afford numerous and magnificent instances of mud volcanoes, accompanied by large issues of naphtha and petroleum in all varieties of condition.

But besides the spots already mentioned, in which petroleum issues in the neighbourhood of mud volcanoes, or in such direct volcanic association that we can at once trace the connecting links, there are others, and those the most remarkable in the world for the actual quantity of mineral oil obtained, where no mud volcanoes are known to be near, and even where there is no volcanic influence of any kind at hand. I allude, of course, to the oil-bearing districts in North America, where the oil rises in quantities proportionate to the magnitude of the coal-fields and to the vast folds of the strata through which it reaches the surface. These indicate geological axes of extreme importance and magnitude; and, although there are no evidences of communication with the interior such as volcanoes offer, there is clear geological proof of the action of upheaving forces on the grandest scale.

Wherever there are deposits of mineral fuel and of large quantities of organic matter accumulated during some past period of the earth's history, there are in the neighbourhood, either oils or bituminous minerals. Bituminous shales, grits, limestones, and even ironstones, so saturated with bitumen that they will yield mineral oils on distillation at a low heat, are met with in most of the coal-fields throughout the world. It does not matter what may be the geological age of the coal, or whether it be coal or lignite. The bituminous mineral also may be of any kind.

If we distinguish between petroleum, in a fluid or thickened state, and bituminous shales, commonly so-called, we shall find that springs of mineral oil rise chiefly in lines parallel to certain great mountain chains.

On the other hand many great deposits of bitumen and bituminized minerals, are less clearly brought into relation with similar causation.

The petroleum springs, so abundant in the Caspian, range along the foot of the Caucasus, and are continued for a long distance in the same direction. They commence again at the foot of the Carpathians, where they abound in Galicia, and are numerous in Wallachia. In both countries the quantity of oil is probably large, and the number of spots whence the mineral has been obtained is, certainly, enormous. We lose sight of them as the Carpathians pass into the Alps, but they recur where the Apennines pass away from the Alps. We find them occasionally on the flanks of the Apennines, but more abundantly in France, where the Alps themselves die away into the plains. They are met with near the outlying coal-fields in the south of France.

But most of all are they abundant and productive in the folds of the great anticlinals in North America.

On the other hand, the richest and most valuable shales and cannel coals are those found in parts of the Scotch, Lancashire, and Flintshire coal-fields, in neither case far from basaltic eruptions of ancient or modern date, but very far from the great mountain chains and axes of main elevation. Other bituminous shales of value occur in other coal-fields, and with or near lignites in many districts, and of all geological ages. Throughout the great plains of Europe there are cases in point which I need not here quote. Others have been described, some very recently, in Australia. Many are known in Asia and America, but most of them are less important. There is hardly a coal-field, and not many beds of available lignite, without bituminous rocks adjoining or enclosing them. This relation, so universal and so widely spread, cannot be without some distinct meaning in the history of the earth.

It would seem clear that the hydro-carbons locked up among the strata of the earth, and now only beginning to be released and rendered useful, are parts of the great history of metamorphosis and change that has affected every deposit during all time.

III. ORGANIC DEPOSITS NEAR MUD VOLCANOES.

The various minerals that, under the names of petroleum, naphtha, bitumen, cannel-coal, and bituminous shales, are now so much sought after, and most of them so valuable, have, in all probability, obtained their carbon from organic deposits. Their hydrogen may have been derived partly from the excess of that gas present in all organic matter, partly from the decomposition of water; and their history, in either case, is connected with that great and systematic metamorphosis induced and constantly in progress in the interior of the earth. A slow distillation of coal or lignite, effected with comparatively little heat, and enduring for a long time under favourable circumstances, must be accepted as the general explanation of the various phenomena. Where, as in Trinidad, the quantity of bitumen is so large, and the production so recent that we can see the process as it has gone on and its actua' progress, we find large deposits of lignite adjacent. In the Caspian Sea, where the flow of naphtha is also enormous, and has continued uninterruptedly for at least 2000 years, there are also lignites near. All along the flanks of the Caucasus, and at the foot of the Carpathians and Alps, and on the Apennines, the same general fact is notorious. The position of the beds of lignite affected is not always traceable, but that the rocks adjoining are loaded with this mineral there is no doubt. The tertiary coal has, in these countries, been largely converted into oil; and if the same has not happened with the coal-fields of Western Europe to so great an extent, the result has been, at any rate, partially produced; and in other old coal-fields, as in North America, the increased thickness and magnitude of the coal deposit is accompanied by a corresponding yield of oil. Everywhere the oils seem to have been obtained as secondary products, and to be due to changes of the nature of distillation. It is probable that the process is one that has always been going on, and that the increased proportion of carbonaceous and bituminous schists among older rocks, is the result of an action continued through much longer time.

It is not difficult to understand that while the slow distillation, at a low heat, capable of producing mineral oil and causing rocks to absorb it, but insufficient to produce combustion, may be most consistent with salses and mud volcanoes, the effect of repeated volcanic eruptions of the ordinary kind may be to destroy the carbonaceous deposits passed through by the conversion of the whole into carbonic acid, carbonic oxide, or, perhaps, in rare cases, by actual combustion. It is, at any rate, certain that while petroleum or bitumen is always the associate of such slow volcanic action as is exhibited in mud volcanoes, it is by no means always to be found in or near volcanoes commonly so called.

It cannot be necessary to point out that the determination of an invariable dependence of mineral oil on organic deposits would be an important step in the discovery of the localities where petroleum is likely to be present. According to present experience, coal and lignites are usually either accompanied by bituminous shales, sandstones, or limestones, or by petroleum springs. On the other hand, petroleum springs are not always to be found where lignites or coal are at hand. It requires another element—namely, disruption of strata or some other indication of disturbance and subterranean movement—in order to ensure the important and useful chemical action by which the hydro-carbons are obtained.

IV. THE COSMICAL RESULTS.

It is certainly an important fact, that if broad lines, or belts, were drawn on the earth to include (1) the various points at which mud volcanoes are known to erupt—(2) those where active or extinct volcanoes, cones, and craters, or surface lavas are observable—(3) those which are remarkable for yielding naphtha or petroleum in a fluid

On the other hand many great deposits of bitumen and bituminized minerals, are less clearly brought into relation with similar causation.

The petroleum springs, so abundant in the Caspian, range along the foot of the Caucasus, and are continued for a long distance in the same direction. They commence again at the foot of the Carpathians, where they abound in Galicia, and are numerous in Wallachia. In both countries the quantity of oil is probably large, and the number of spots whence the mineral has been obtained is, certainly, enormous. We lose sight of them as the Carpathians pass into the Alps, but they recur where the Apennines pass away from the Alps. We find them occasionally on the flanks of the Apennines, but more abundantly in France, where the Alps themselves die away into the plains. They are met with near the outlying coal-fields in the south of France.

But most of all are they abundant and productive in the folds of the great anticlinals in North America.

On the other hand, the richest and most valuable shales and cannel coals are those found in parts of the Scotch, Lancashire, and Flintshire coal-fields, in neither case far from basaltic eruptions of ancient or modern date, but very far from the great mountain chains and axes of main elevation. Other bituminous shales of value occur in other coal-fields, and with or near lignites in many districts, and of all geological ages. Throughout the great plains of Europe there are cases in point which I need not here quote. Others have been described, some very recently, in Australia. Many are known in Asia and America, but most of them are less important. There is hardly a coal-field, and not many beds of available lignite, without bituminous rocks adjoining or enclosing them. This relation, so universal and so widely spread, cannot be without some distinct meaning in the history of the earth.

It would seem clear that the hydro-carbons locked up among the strata of the earth, and now only beginning to be released and rendered useful, are parts of the great history of metamorphosis and change that has affected every deposit during all time.

III. ORGANIC DEPOSITS NEAR MUD VOLCANOES.

The various minerals that, under the names of petroleum, naphtha, bitumen, cannel-coal, and bituminous shales, are now so much sought after, and most of them so valuable, have, in all probability, obtained their carbon from organic deposits. Their hydrogen may have been derived partly from the excess of that gas present in all organic matter, partly from the decomposition of water; and their history, in either case, is connected with that great and systematic metamorphosis induced and constantly in progress in the interior of the earth. A slow distillation of coal or lignite, effected with comparatively little heat, and enduring for a long time under favourable circumstances, must be accepted as the general explanation of the various phenomena. Where, as in Trinidad, the quantity of bitumen is so large, and the production so recent that we can see the process as it has gone on and its actual proximate cause; and also to inter-communication of volcanoes in the same district, if not throughout the same hemisphere. No eruption has ever taken place without the evolution of enormous quantities of steam. Puffs of steam, occurring at intervals, are the first phenomena of volcanic action, whether on a small or large scale. Water issues from mud volcanoes. The presence of soda, often in the state of carbonate, amongst lavas is a fact well known, and of which I have seen many examples in recent eruptions, both of Etna and Vesuvius. Chlorine also is a gas invariably present during the early and active times of an eruption. Thus it is more than probable that sea-water obtains access to the cavities in which the eruptions originate, or through which the erupting matter passes. The substances erupted from all volcanoes—mud volcanoes included—consist of the materials, more or less altered, of the deposited rocks adjacent. From mud volcanoes iron-oxide, and even lignite, have been thrown out in addition to the tenacious clay.

Whatever may have been the original cause determining the direction of cavities within the earth's crust, it would seem that they cannot be very far beneath the surface, and that they affect only limited though large areas. Nor do they seem to demand a temperature greater than may be due to the interruption of magnetic currents through materials of different conducting powers. The access of sea-water through natural fissures into such cavities moderately heated, accounts for the phenomena produced; namely, the upheaval of continents by the expansive action of steam, and the occasional interruption of upheaval by volcanic eruptions; the steam thus finding partial and interrupted vent through cracks and fissures produced during elevation. No doubt, to render this explanation sufficient, it must be granted that such systematic cavities extend for thousands of miles beneath the outer surface of the earth, and are at no considerable depth in proportion to the earth's radius.

I believe that to water, and the circulation of water, upheaval as well as denudation are probably due. It is not the whole or any part of the compact and continuous dense crust of the earth that is disturbed by volcanic upheavals or the elevation of continents, but only a few of the upper films, so that in different parts of the crust such upheavals may be produced in very different directions. At the same time, the causes that act in producing volcanoes and elevating the earth's surface act on a grand scale, even when measured in reference to the whole surface of the earth, and as they affect large areas, so do they range over very extended periods.

That during the progress of eruptions, and for a very long time after every eruption, vapours and gases continuing to pass through the crevices and pores of rocks, greatly modify them, and produce an enormous and never-ceasing amount of chemical change there cannot be a doubt. It is in reference to considerations of this kind that the whole subject of metamorphosis comes under the domain of the geological chemist rather than the mere geologist, and renders it difficult for the latter to satisfy himself, or arrive at definite results without the aid of chemistry. The production of petroleum is one among many such changes. A mud volcano and the petroleum spring adjacent are derived from eruptions of steam and certain gases passing through certain minerals, of which shale and lignite are the best examples. The vapour, originally at high temperature, on passing through organic deposits has become itself decomposed, and has also slowly decomposed and distilled the organic matter. One portion of its carbon has combined with the liberated hydrogen, and another part with the liberated oxygen. The decomposed vapour of naphtha and the carbonic acid gas having thus risen together towards the surface, the steam and naphtha vapour have liquefied as they cooled. When they have risen through clay and not through melted lava, they have become loaded with mud and cooled as they approached the surface. Cold mud is then erupted instead of hot steam and volcanic dust. The jet is less violent and the eruption slower but more continuous. Part of the naphtha floats on the water, and part is absorbed by the rocks through which it passes.

It often happens that mere heated waters or thermal springs rise through sandstones, limestones, or granite, where there has been no clay, lignite, or coal. When this is the case, a water instead of a mud volcano is produced; and here there is no naphtha or bitumen. Under some circumstances, again, the naphtha is forced up to the surface, through a crevice, without the water; and then there is a naphtha spring, subject to the same mechanical laws as sometimes produce natural artesian jets, with or without water. In the other case, the mineral oil, if unable to reach the surface, penetrates the rocks, and renders them bituminous. Hence we have bituminous shales, sandstones, and limestones, or even, as shown at釋Paternó, bituminous basalts —the rocks being more or less valuable, according to the degree with which they have been charged with bitumen. In this way also have been formed the richer varieties of cannel, such as those of Flintshire, and also those valuable Scotch deposits of exceptional minerals known as Boghead, Torbane Hill mineral, &c. The coal measures also everywhere abound with bituminous shales, clays, and even ironstones. These are very common, though they are rarely bituminous to such an extent as to pay for distillation.

I have already pointed out that where these deposits are chiefly valuable there is generally proof of volcanic action not far off. Thus the Boghead mineral is not far from the basalts of Edinburgh, while the rich Leeswood and other cannels are not far from the line of eruption of the basalts of Shropshire. Although on a far grander scale, the great oil deposits of North America seem to have had a similar origin, and to be connected with upheaval. On the east side of North America it is true there is a little appearance of recent volcanic action, but the rich oil wells are in the line of the great folds of the strata, the geological axis of the country.

I believe then, that the study of mud volcanoes and petroleum deposits leads to the conclusion that both belong to one great systematic series of movements, identical with those which have elevated the great continents; and that the existence of mineral oil in available quantities is determined by the previous accumulation of organic deposits, and the metamorphosis of these on lines of volcanic action.

Where volcanic force is powerfully exercised, and where it occurs from time to time at some one or other definite point in a wide area, it seems to have affected, with tolerable regularity, certain belts of land. In these cases, the liberated steam and gases, in their passage to the surface, have sometimes met the conditions rendering a very slow distillation of organic matter possible or inevitable. The result of such distillation has been the production either of naphtha or petroleum, rising in oil springs, or of bituminous rocks retaining the naphtha or petroleum in their solid substance. To know the probable state of any deposit, the geological conditions therefore must be studied, as it is only thus that we can determine where and how oil is likely to be found, by boring or sinking. On the other hand, there can be no doubt that a practical knowledge of the conditions and localities in which mineral oil has been hitherto obtained in oil-bearing districts, must be extremely suggestive to the geologist and physicist; for there is much still to be learnt by close observation, which, when thoroughly understood, will render intelligible numerous changes and transformations in reference to this matter which are now sufficiently mysterious.

[D. T. A.]

NOTE.—Since the above was in type, I have received from Professor Sylvestri, of Catania, a detailed account of the eruption of Paternó. The muddy water issuing at a temperature of 16° C. was of the S. G. 1·1469, and gave an alkaline reaction. The marly matter suspended in the matter was 12·63 per cent. of the whole. When filtered the S. G. of the water was 1·053, taste very salt and slightly bitter. It contained 6·84 per cent. of soluble salts, including bicarbonates, sulphates, phosphates, nitrates (trace), chlorides, bromides, iodides, and fluorides. The bases included sodium, potassium, cæsium, rubidium, calcium, magnesium, aluminium, lithium, and iron. As much as 6 per cent. consisted of chloride of sodium. The gas contained in the water was almost entirely carbonic acid gas, with a small quantity of oxygen and nitrogen.

The erupted gases were as follows (mean of four analyses):—

	At ordinary Temperature.		At high Temperature.
Carbonic Acid	95·42	..	92 53
Oxygen	0·77	..	0·12
Nitrogen	2·97	..	4·70
Carburetted hydrogen	0·96	..	1·49
Hydrogen	0·55	..	0·99
Sulphuretted hydrogen	..	..	0·30
	100·67	..	100·13

There was also a small quantity of vapour of naphtha.

[D. T. A.]

WEEKLY EVENING MEETING,

Friday, May 18, 1866.

Sir Henry Holland, Bart., M.D. D.C.L. F.R.S. President, in the Chair.

The Rev. Charles Pritchard, F.R.S.
PRESIDENT OF THE ROYAL ASTRONOMICAL SOCIETY.

On the Telescope: its Modern Form, and the Difficulties of its Construction.

In the museum at Naples, among other articles exhumed from the volcanic mud of Herculaneum, will be found the contents of a lapidary's shop; the visitor may there see the half-finished gems, and the tools with which they were being engraved at the moment of the workmen's fright. By the side of them is a piece of glass, rudely shaped into a convex form; and this appears to be the first record of the existence of a lens. It had evidently been used for the purpose of magnifying the microscopic cuttings on the gems necessary to produce the intended effect.

Thirteen hundred years after this, spectacle-glasses had become somewhat common in Europe, and it was by a combination of these that one Hans Lippershey, in the year 1608, at Middleburg, in the Netherlands, invented a telescope, by means of which distant objects "were brought nearer." Several of these instruments, very early in the year 1609, were provided in a binocular form, for and at the expense of the States-General of the Netherlands; but there is no record of their having been directed to any astronomical object. In May, 1609, Galileo, at Venice, heard of this new invention, without, so far as is known, any precise intimation of the method by which the effect was produced. He hastened home to Padua, and on the day after his arrival he produced the form of telescope which still bears his name. His first instrument magnified but three times. Very shortly afterwards he constructed a second telescope, possessing a power of about six linear. With this he discovered the satellites of Jupiter, in January, 1610. He also observed spots in the sun, and mountains in the moon. Very soon after these discoveries, Galileo succeeded in constructing a telescope which magnified about thirty-three times linear; and with this he discovered the long-suspected phases of the planet Venus, thereby completing the proof which was still wanting of the truth of the Copernican system. There can be little doubt that the intellectual convictions which necessarily followed upon this discovery, emancipated mankind from the thraldom of the dogmas of the Aristotelians and the Schoolmen, while, at the same time, they consigned Galileo to the persecutions of the Inquisition, and deprived him ultimately of his personal liberty. It is remarkable that, so far as the means then in existence permitted, Galileo carried his particular form of telescope to its furthest practicable limit of perfection.

For some forty years the telescope remained in the form in which Galileo left it. In 1656, Huyghens, at the Hague, substituted two convex lenses in contact for the eye-glass instead of the single concave lens employed by Galileo. This contrivance materially increased the field of view, and with such a telescope, now extended to the lengths of twelve feet and of twenty-three feet, Huyghens discovered Saturn's ring, supposed by Galileo to consist of two small spheres, one on either side of the planet. He also discovered one of the satellites of Saturn, and he contrived that admirable form of eye-piece called the Huyghenian, which, with no material improvement, is still in constant use at the present day. The field of view was again so greatly increased by this invention that Huyghens was enabled to make use of telescopes of the length of even 120 to 160 feet.

The enormous length which was at this time necessary to assign to a telescope in order to produce what is now considered a small amount of amplifying power, put a natural and very confined limit to the practical application of the instrument. The causes which necessitated this great length of the instrument, combined at the same time with very narrow limits to the size of the object-glass, were principally two, independently of the impossibility of procuring homogeneous glass of large dimensions.

First, the effect of a lens upon a pencil of light incident upon it, is to spread it out into a coloured circle, of which the diameter is, with ordinary glass, about one-fiftieth part of the diameter of the object-glass. This defect—if the consequence of a natural law can be properly termed a defect—evidently set a natural limit not only to the size of the object-glass, but to the amount of magnifying power applicable to the eye-piece, thus necessitating the twofold inconvenience of contracting the size of the object-glass, and of producing power in the telescope by the increase of its length.

Newton, by unfortunately making use of a certain species of Venetian glass of low specific gravity, and very much resembling water in its optical properties, came to the conclusion that it was not possible to obtain optical or magnifying power without, at the same time, producing the dispersion of colour, which, as we have seen, is inconsistent with clear definition in telescopes of manageable dimensions.

In 1758, John Dollond, by experimenting with glass of a different character to that employed by Newton, discovered the source of that great philosopher's mistake. He found that a lens of the ordinary heavy metallic glass of his day, called flint-glass, dispersed the colour of a pencil of light about as much as a lens of crown or plate-glass, possessing double the general deflective or magnifying power of the former. Hence, by combining a convex lens of plate-glass with a concave lens of flint-glass, but possessing only half the power (in this case a diminishing power), he obtained a combination which was capable of forming a nearly colourless image.

We say *nearly* colourless, because the powerful plate lens acts, from the nature of the material, more powerfully in refracting the middle or green portion of the spectrum than can be recovered by the contrary action of the correcting or flint concave lens. Hence, there remains behind an uncorrected or residuary spectrum of about $\frac{1}{30}$th of the breadth of the original spectrum produced by the convex plate lens—that is to say, a pencil of white light is now dispersed over a circle whose diameter is about $\frac{1}{3000}$th part of that of the object-glass. In the best modern telescopes this defect is left to its fate. Mr. Cooke is at this moment engaged in the construction of an object-glass twenty-five inches in diameter, by far the largest ever yet attempted. The diameter of the circle and chromatic diffusion in this magnificent object-glass, when completed, cannot be less than about $\frac{1}{120}$th of an inch: unless, therefore, some secondary combination is introduced, this circumstance will unavoidably prevent the employment of any powerful eye-piece.

The necessity of employing small object-glasses was thus satisfactorily removed by the discovery of Dollond in 1758. Nevertheless, there still remains another serious cause of imperfection in the compound object-glass. Generally speaking, any lens, of which the surfaces are spherical, is much more powerful towards the margin than are the parts of it near to the centre. A pencil of light, incident on the whole aperture of a lens will, in general, be diffused over a circle whose diameter bears a very appreciable ratio to the thickness of the lens. Happily, however, the actions of a convex and of a concave lens are, in this respect, in opposite directions, and hence they have, when combined, a tendency to correct or compensate the spherical aberrations of each other. Still more happily, the amount of this spherical aberration depends very materially on the *relative* curvatures of the two surfaces of the lens. Without altering the focal length of a lens, it is quite possible very seriously to alter the amount of the spherical aberration. For instance, in lenses of any material, the aberration of a plano-convex lens is four times that of a lens of equal power, where the curvature of the side facing the incident light is three times that of the other surface. This remarkable effect arises from the circumstance that, although upon the whole, the same total deviation of the light is produced in the two lenses, the distribution of the amount of deviation to be produced by each surface in its turn is very different. By the application of these principles it has become comparatively easy to produce a combination free both from primary chromatic, and from spherical aberration. The correction of the colour by a concave flint lens depends, speaking roughly and in *general*, on its focal length, and not upon the relative curvatures of its surfaces; consequently these relative curvatures can be altered until those are found which balance the spherical aberration of the convèx plate-glass lens. The investigation of the best methods of obtaining these appropriate relative curvatures is attended with extreme labour and much difficulty, and has occupied the thoughts of a long succession of accomplished mathematicians. The main source of difficulty has been supposed to arise from the necessity of taking the *thicknesses* of the lenses into the account. Mr. Pritchard, however, has recently shown that the thicknesses of the two lenses have a tendency to compensate one another in the amounts of spherical aberration which they respectively either introduce or remove, and he has demonstrated that tables constructed on the principle of neglecting the thicknesses, are practically applicable to all such cases as *ordinarily* arise in the construction of the aplanatic object-glasses of modern telescopes.

We may consider then that the once difficult question of the removal of spherical aberration in an object-glass as now practically solved, and that too in a manner which requires but little further trouble than the inspection of a set of tables. There does, however, still exist a practical difficulty, where theoretically there was, or even now is, supposed to be none. It is almost universally asserted in treatises upon the subject, that in order to produce an achromatic combination nothing further is required than to make the focal lengths of the two lenses proportional to the dispersive powers of the materials of which they consist. Practically, and even theoretically, this is not the case; but, on the contrary, the proper ratio of the focal lengths of the two lenses is perceptibly influenced by the *forms* or curvatures of the lenses themselves. It is herein that the eye and the skill of the optician are required; and (perhaps unexpectedly) it is in this direction that we are to look for one of the weakest and most troublesome elements in the construction of the object-glasses of telescopes. Such, however, has been the improvement in the manufacture of glass in England, and such is the ability of modern English artists, that there is good reason for believing they have now regained the ancient supremacy, which in this respect existed in the time of Dollond.

[C. P.]

WEEKLY EVENING MEETING,

Friday, May 25, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

A. S. Herschel, Esq. B.A.

On the Shooting-stars of the years 1865-6, *and on the Probability of the Cosmical Theory of their Origin.*

Attention was recently directed by Professor Newton,[*] of Yale College, U.S., to the probability, on well-considered grounds, that in the current year, 1866, a prodigious flight of meteors, the most imposing of its kind, and visible over a large area of the earth's surface, will make its appearance—perhaps for the last time in the present century—either on the morning of the 13th, or on the 14th of November. The rare opportunity thus afforded of deciding some important questions in the theory of shooting-stars makes it a matter of special interest for persons skilled in such accurate observations, to watch for its return on each of the mornings named (wherever practicable, between one and two o'clock[†]), to obtain the necessary data. The phenomenon at its maximum was seen by Humboldt, at Cumana, on the morning of the 12th of November, 1799; and again by Dr. Denison Olmsted, in its greatest brilliancy, at Newhaven, U.S., on the morning of the 13th of November, 1833. Olmsted was the first to sum up, in the following general language, the chief characteristics of the display:—

1. The number, *especially of bright meteors*, is much larger than usual.
2. An uncommonly large proportion *leave luminous trains.*
3. They proceed, with few exceptions, from a common centre in some part of the constellation *Leo.*
4. They are seen from midnight to sunrise, *and in greatest abundance between three and four* A.M.

---

[*] 'American Journal of Science,' 2nd series, vol. xxxvii. p. 377; and vol. xxxviii. p. 53.

[†] The object in restricting the watch to a particular hour is, that as many meteors as possible *may be simultaneously observed at distant places.*

These characteristics were regarded by Olmsted as sufficient to identify for the future the return of the November shower. Observers who endeavour to verify the truth of this description for themselves will be enabled by so doing, to furnish invaluable materials for future investigations. The same features are, moreover, of peculiar interest, since they have been found to characterize, with certain differences, a number of other meteoric showers.

The periodicity of the well-known shower of meteors on the 10th of August was discovered independently by Quetelet, in the year 1836, and by Herrick (not knowing what Quetelet had predicted) on the reappearance of the same meteors in the year 1837.* At their next return, on the 10th of August, 1839, it was shown by Littrow† that a star-shower, whose occurrence in A.D. 1451, on the 5th of August, N.S., is cited by Biot from the 'Chinese Annals,'—compared with another that appeared, according to the same authority, in A.D. 830, on the 26th July, N.S.,—gives 365 d. 6 h. 12 m. as the average length of the interval between any two successive returns of the August meteors; and again, that the same star-shower compared with that of the 10th of August, 1839, gives 365 d. 6 h. 8 m. as the average length of the same period,—the mean of the two determinations being 365 d. 6 h. 10 m., which is twenty minutes longer than the civil or tropical year; *but differs less than one minute from the sideral year.* Besides the displays of the August meteors which happened about the year A.D. 830, other returns of the August meteors, of the nature of star-showers, are recorded in the 'Chinese Annals'‡ to have happened at the end of July, N.S., about the year A.D. 933; and another is cited by Herrick which happened on the 2nd of August, N.S, in the year 1243. The meteoric year of August, therefore, coincides with the sidereal year; and a period of 103 years brings all the star-showers of A.D. 830, 933, 1243, and 1451 into conjunction with the remarkable star-shower of the 10th of August, 1863. A star-shower is cited, moreover, by Biot, which happened at the end of July, N.S., in the year A.D. 833. A return of this star-shower may not unreasonably be expected to occur on the night of the 10th of August, 1866.

Between the 13th of October and the 13th of November, during the years from A.D. 903 to 1833, not less than thirteen great star-showers have been recorded. They are separated from each other by the third part of a century, or by some multiple of this period, and are periodical re-appearances of one grand meteoric shower,

---

* 'American Journal of Science,' 1st series, vol. xxxiii. pp. 176, 354; and vol. xxxvii. p. 338.

† 'Astr. Nachr.,' vol. xviii. p. 374.

‡ Regarding the visibility of the August meteors in China, Captain Sherrard Osborn, C.B. R.N. &c., relates that they were seen by the watch on board the 'Furious,' near Yedo in Japan, on the night of the 9th—10th of August, 1858, shooting by hundreds from the north-east to the west overhead.—*Cruise in Japanese Waters*, p. 102.

viz. that seen by Humboldt in 1799, and by Olmsted in 1833—the star-shower expected to return in the present year, and known by the name of the 'Great November Shower.' Its encounter with the earth takes place one day later in the year at each of its principal returns. According to the exact calculations of Professor Newton, the next passage of the earth through the centre of the meteoric group will take place two hours after sunrise at Greenwich, on the morning of the 14th of November, 1866.* As, however, the phenomenon occurred upon the morning of the 13th, in each of the years 1864 and 1865 (and not so brightly upon the 14th), its moment of greatest brightness may, possibly, fall one day earlier than the predicted time, and a watch on both mornings, of the 13th and 14th, is accordingly recommended to be kept. The meteors being seen from midnight to sunrise, the hour from one to two o'clock is the best that can be chosen, as being the most convenient for making simultaneous observations.

On the morning of the 13th of November, 1865, the meteoric shower in England was observed at the Greenwich and Cambridge Observatories, at Hawkhurst, and at other places. The hourly number of meteors is stated by Mr. Glaisher and by Prof. Challis to have exceeded all before recorded at either of those Observatories. More than 250 meteors (279) were recorded at Greenwich from midnight until five o'clock, when for a space of nearly a quarter of an hour the paths of the meteors among the stars, &c., were not noted, but their number was simply counted. The result was, that at this time meteors of the first class were appearing at the rate of 250 per hour. At least a thousand meteors must have been visible at Greenwich from one to five o'clock on the morning of the 13th. They were only seen *after* midnight, until near sunrise, and they were most abundant during the hour from one to two o'clock. The maximum display of the November meteors expected in the year 1866, is still several hundred times greater than that observed at Greenwich on the 13th of November, 1865. *Two hundred and forty thousand* meteors are computed by Arago to have been visible above the horizon of Boston on the morning of the 13th of November, 1833.† Hundreds of the meteors seen on that occasion appeared brighter than the planets; and some of them were fireballs of the largest class.

Nearly two-thirds (172) of the meteors seen at Greenwich left luminous trains, visible for several seconds after the disappearance of the meteors. Their unusual number, and the appearance of the luminous trains which they left behind them, agree with Olmsted's description of the meteors in 1833, and leave no doubt of the return of the November shower. Its reappearance in the present year, there is every probability, will entitle its next return to the name of the 'Great November Shower' of 1866.

---

* 'American Journal of Science,' 2nd series, vol. xxxviii. p. 60 *et seq.*

† Mr. Greg informs the writer that, as seen by Mr. Baxendell, F.R.A.S., on the west coast of Mexico, "The number of meteors seen at once, often equalled the apparent number of the fixed stars seen at a glance!"

Amongst the list of shooting-stars seen at Hawkhurst last November, seventeen were identical with meteors observed at Greenwich. Fifteen other meteors of the list were identical with meteors seen at Cambridge. The heights, lengths of path, &c., of ten of these accordant meteors were calculated, and this is also the number of accordances calculated by Dr. Heis of Münster. The average heights obtained at both places are entered in the following table for comparison:—

	Mean Heights of Ten November Meteors observed at	
	1. Hawkhurst. Brit. Stat. Miles.	2. Münster. Brit. Stat. Miles.
Mean height at first appearance	74	77
Mean ditto at disappearance	54	44
Mean ditto at centres of visible paths . . .	64	61

The average height of the centres *is a little greater* than the commonly received height of shooting-stars. Professor Newton has shown that the ordinary height of shooting-stars at the middle of their apparent paths is *not quite sixty miles above the surface of the earth.*[*]

The divergence of the November meteors in the year 1865 from a common centre in the constellation *Leo*, was noted both in Europe and America, and the following positions were obtained:—

Place, and Observer's Name.	Position of Radiant Point, Nov. 13th.	
	R.A.	N. Decl.
Greenwich (Mr. Glaisher)	160°	30°
Hawkhurst (Mr. Herschel)[†] . . .	150	20
Münster (Dr. Heis)	148	24
Newhaven, U. S. (Prof. Newton) . . .	148	23
Philadelphia, U. S. (Mr. Marsh) . . .	148	24

The average of these positions is some degrees from the bright star γ *Leonis*, of which the position is in R.A. 153°, N. Decl. 21°; nevertheless the close agreement of the last three places of the list merits particular attention.

The following radiant points of special meteor-showers were recorded at Hawkhurst during the last few years, by the aid of star maps expressly suited to the purpose.—Views of the original observations drawn on punctured maps showing the radiant points, were exhibited, by Dr. Tyndall's assistance, on the white screen.

---

[*] 'American Journal of Science,' 2nd series, vol. xxxix. p. 194.

[†] 'Astronomical Register,' No. 37, p. 18.—The radiant point of thirty-five meteors observed during the hours *from one to three o'clock*, was in right ascension 148°, north declination 23°,—exactly the position assigned by Professor Newton. (A. S. H.)

METEORIC PERIOD.[*]	Date of Observation.	Position of the Radiant Point. R.A.	Position of the Radiant Point. N. Decl.
Jan. 2-3	1864	234°	51°
Apr. 9-11	„	192	4
„ 19-21	„	278	35
Aug. 9-11	1863	44	56
Oct. 18-20	1864-5	90	16
Nov. 12-14	1865	150	20[†]
Dec. 11-13	1863-4	101	34

A number of observations of luminous meteors contained in the Catalogue of the British Association, from the year 1845 until the present time, are capable of being classified in a similar manner, and upwards of fifty radiant points of shower-meteors throughout the year are recognized as coinciding in their epochs and positions with the epochs and positions of similar radiant points observed by Dr. Heis. Charts of these meteors are now in process of completion, and a first step will be gained thereby, towards establishing a regular shower-meteor theory. When the principal meteoric showers, and their connected radiant points, and epochs are pointed out, what are commonly called "sporadic" shooting-stars will become extremely scarce.

A few instances lately brought to light will show that aërolites and fireballs are not only independent of geographical position, but that they are also fixed in their dates of appearance and directions. Two stonefalls took place on the 25th of August, 1865; one at Aumale, in Algeria, the other at Shergotty, in India. Two detonating meteors of the largest class were seen in December, 1865; one on the 7th, at the mouth of the Loire, the other on the 9th, at Charleston, U.S. Three detonating meteors, on the east coast of England alone, during the last five years (1861-5), occurred between the 19th and the 21st of November. Two of the latter meteors, whose paths could be traced, proceeded from a common centre in some part of the constellation *Cetus*. A bright fireball was seen at Hawkhurst on the morning of the 9th of December, and another at Manchester on the morning of the 13th of December, 1864, whose paths (continued *backwards*) proceeded directly from the radiant point of the period mentioned last in the foregoing list. A notable peculiarity in respect of general geographical distribution, periodical returns, and fixed directions would evidently connect aërolites and fireballs in true astronomical relation with ordinary shooting-stars. Nevertheless it appears that out of 72 aërolites whose hour of fall is certainly known, by far the greater number (58) occurred *after midday*, during the hours from noon to nine P.M.[‡] Shooting-stars, on the contrary, reach their maximum at an opposite hour of the day, being found to be most abundant *after midnight;* or twelve hours later. An astronomical difference accordingly exists between aërolites and shooting-stars, to which it is not impossible that a physical difference of a kind not yet established should correspond. It is noticed, for example, that on the 10th of August, and the 13th November, dates on which shooting-stars and fireballs are more abundant than on any other nights in the year, *but one stone has fallen* on each date. The average height of seventy-eight meteors observed in America on the 13th of November, 1863, exceeded the usual height of meteors by fifteen or twenty miles.* On these grounds Professor Newton supposes that the November shower-meteors are composed of more easily destructible, or of more inflammable materials than aërolitic bodies. An examination of the light of shooting-stars (and particularly of the November meteors) by means of the spectroscope, would at once reveal the fact if these meteors and their luminous trains are composed of substances in a gaseous state; *the presumption is that they are solid*, although probably in a state of fine division. Whether shooting-stars consist of particles in a state of dust, or vapour, which the spectroscope can alone reveal, the return of the Great November Shower is a favourable opportunity for advancing our knowledge by its use, and a discovery is in store for refracting prisms, which should not (if possible) be allowed to pass away unheeded.

---

[*] These meteoric periods are advanced by Baumhauer, as dates on which fireballs are most common. 'Poggendorff's Annals,' vol. lxvi. p. 471. 1845.

[†] *See* note (†), p. 648.

[‡] Only thirteen fell in the forenoon, and fifty-eight during the hours from noon to nine P.M. 'B. A. Report—1860,' p. 26.

The spectrum of an entire star-shower was shown, by Dr. Tyndall's assistance, upon the screen with a straight-vision prism having a direct field of view of at least 20° of the sky.† The meteors were illuminated first by the carbon points of the electric lamp, and afterwards by the vapour of silver in the electric arc, showing the different appearances in the prismatic field of view, of a solid, or a gaseous source of light. Some tinder was ignited by a fire-syringe; and experiments with Gassiot's Geissler tubes were shown to illustrate the difference that exists, between the diffuse glow of an electric discharge, resembling the aurora in the highest and rarest strata of the atmosphere, and the massive light of meteors, resembling an ordinary spark.

[A. S. H.]

---

* 'American Journal of Science,' 2nd series, vol. xl. p. 252.

† A pair of such prisms, mounted upon a binocular frame, is recommended as the best instrument for meteospectroscopic observations. Mr. Browning constructs a Binocular Pattern of Dense Glass Prisms shown at the lecture, under the name of a "Meteospectroscope."

WEEKLY EVENING MEETING,

Friday, June 1, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

Henry E. Roscoe, B.A. F.R.S.

On the Opalescence of the Atmosphere.

On a previous occasion (May 22, 1864) the speaker explained the principles of a method by the application of which we are able to gain some knowledge of the distribution of the chemically active rays on the earth's surface, and their variation from time to time. This method depends upon the comparison of tints gained by sensitive photographic paper when exposed to daylight; and it is evident that we must define the "chemical rays" to be all those which are able to produce a darkening effect upon chloride of silver paper. In order that such a mode of measurement should be possible, it is necessary, in the first place, that paper can be prepared of a uniform degree of sensitiveness; and secondly, that the relation between the several tints and the intensity of the light necessary to produce such tints should be known. These relations have been accurately ascertained, and the method is now so far perfected that the observations can be very easily and accurately made.[*]

The whole apparatus needed for these experiments is contained in a small box, and all the observations for a day can be made in the course of a few minutes.

Through the kindness of Mr. Balfour Stewart, determinations of the Chemical Intensity of Total Daylight have been carried on at Kew Observatory for the past year by Mr. T. W. Baker. The mean daily intensity can be readily obtained from the separate observations, and these, when plotted out as a curve, show the daily mean intensities for the year.

Daily Mean Chemical Intensities measured at Kew, April, 1865, *to April*, 1866.

For April, 1865	81·2	For October, 1865	29·2
„ May „	97·0	„ November „	12·8
„ June „	76·9	„ December „	6·9
„ July „	100·6	„ January, 1866	13·4
„ August „	82·5	„ February „	24·2
„ September „	110·2	„ March „	32·2

In Spring, 45·9 In Summer, 91·5 In Autumn, 73·9 In Winter, 11·0

(Light of the Intensity 1 acting for 24 hours taken as 1000.)

---

[*] See 'Phil. Trans.,' 1865, p. 605: "The Bakerian Lecture."

It is seen that the condition of the sky and weather materially influences the chemical intensity of the month—thus June, 1865, was cloudy (2 days rain; 21 days cloudy; average amount of cloud, 5·5), and the mean intensity is 76·9; whereas September was a very bright month (0 days rain; 20 days cloudy; average amount of cloud, 2·5), and the chemical intensity reached 110·2.

If we compare the mean intensities for the summer and winter solstices and the equinoxes as measured at Owen's College, Manchester, we have,—

June 21	**113**
March and September 21	**33**
December 21	**4·7**

The above numbers show that the increase of chemical action from December to March is not nearly so great as that from March to June. This difference cannot be attributed to the common absorption exerted by the atmosphere, but may be explained as being the necessary consequence of a peculiar absorptive action which the atmosphere effects upon the chemically active rays, and to which the name of opalescence may be given.

It has frequently been stated* that the chemical intensity of light on snowy peaks and in tropical climates is much less than that in our own latitudes, and that photographers in Mexico have found it impossible amidst the glaring rays of a tropical sun to obtain a picture which in the gloomy atmosphere of England would need an exposure of only one minute. In order to ascertain the degree of truth attaching to these extraordinary statements, and to obtain some insight into the chemical intensity of tropical climates, the speaker was fortunate to be able to send his assistant, Mr. T. E. Thorpe, to Pará, on the Amazons (long. 48° 30′ W., and lat. 1° 28′ S.). The measurements there made have already furnished some very interesting results; in the first place, we find that the daily mean chemical intensities at Pará and at Kew on the same days are represented by the following numbers:—

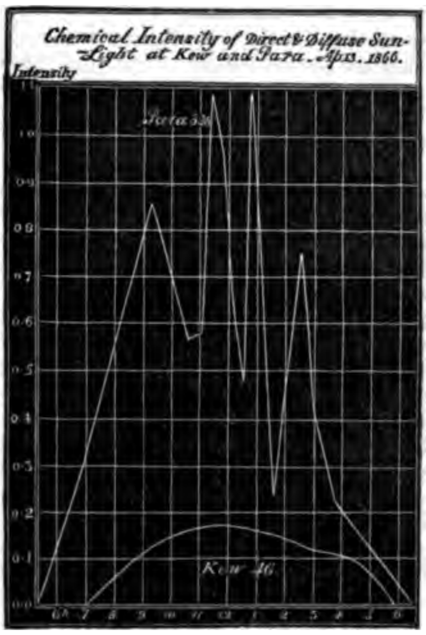
	Kew.	Pará.	
April 4, 1866	19·7	260·0	or as 1 to 13·1
,, 7 ,,	9·3	320 0	or as 1 to 34·4
,, 13 ,,	45·7	326·0	or as 1 to 7·1

The curves for these days show the enormous variation of chemical intensity which occurs under a tropical sun during the rainy season. Every afternoon regularly, and sometimes at other periods of the day, the enormous thunder-clouds discharge their contents in the form of deluging rain, and the chemical action sinks to zero; then the storm passes over, and the chemical intensity again rises (see woodcut on opposite page). It is thus seen that any difficulties which a photographer may have in the tropics cannot be ascribed to an insufficient supply of the sun's chemically active rays.

---

* See Golding Bird, 'Natural Philosophy,' 5th edition, p. 622.

The speaker desired, however, chiefly to direct attention this evening to some experiments which appear to throw light upon that much vexed question of the cause of the blue colour of the heavens and the ruddy tints of sunrise and sunset. Since the time of Leonardo da Vinci this subject has been a favourite ground for the display of meteorological speculations. Leonardo, and afterwards Goethe, believed that the blueness of an unclouded sky was due to the passage of the white light through the atmosphere containing finely-divided particles. Newton explained the blue colour of the heavens by the existence in the atmosphere of hollow very minute vesicles of water, upon which, as on a soap-bubble, the colours of thin plates become perceptible; and according as the thickness of the walls of these vesicles increased, so would the colour change from blue to yellow, orange, and red; and thus, by very frequent reflections, the various tints from sky-blue to sunset-red could be explained. Founded upon this theory Clausius has calculated the relative intensities of direct sunlight and the diffuse reflected light of the sky for varying altitudes of the sun.



Some physicists have assumed that the air itself has a blue colour, whilst others have admitted that if air be of a blue colour by *reflected* light, it must appear red by *transmitted* light.

Others again, in order to avoid the difficulty of explaining the great variety of sunset tints, have assumed these tints to be an ocular deception, or caused by the presence of clouds which receive and repeat the colour!

Many physicists have suggested that the atmosphere, being filled with small particles of floating solid matter, acts like an opalescent medium and transmits only red light; but it is to Brücke* that we are indebted for a complete statement and masterly investigation of this view of the subject. Forbes, again,† explains the phenomena in an entirely different manner; for he, observing that under certain circumstances aqueous vapour, or rather water in finely divided particles, is able to absorb the blue rays, and that the sun looked red when seen through a particular portion of a jet of escaping steam, attributes the sunset-red solely to the presence of water in this peculiar state of division.

In order to appreciate the value of these various opinions, it appears of special interest to obtain a knowledge of some quantitative facts respecting the intensity of the light transmitted directly from the sun, and that reflected by the air or particles in the atmosphere The possibility of making such measurements with respect to those parts of the sun's light which may be expected to show great differences in reflection and transmission, *viz.* the most refrangible portions, is rendered at once evident by the employment of the simple method of measuring the chemical intensity of light which has been above alluded to. The method employed consists simply in determining the chemical intensity of the total daylight (sunlight and diffused light), and immediately afterwards shading off the sun's direct rays by means of a small disc or sphere of metal, whose apparent diameter is only slightly greater than that of the solar disc seen from the position of the sensitive paper. In this way the chemical intensity of the total (direct and diffused) light is compared with that given off by the whole of the heavens alone, and the difference gives the chemical intensity of the direct sunlight.

Experiment soon proved that the relative intensity of the chemical light coming directly from the sun is very much less than we should ordinarily suppose, judging from the intensity of the visible light. Thus, at Owen's College, Manchester, it was found when the sun was 12° 3′ above the horizon, that of 100 chemically active rays falling on the horizontal surface, less than 5 were due to the direct sunlight, whilst 95 came from the diffused light of the heavens, even when the sky was unclouded. At the same instant, of 100 rays of visible light as affecting the eye, 60 came directly from the sun, and only 40 from the diffuse sky-light. This singular result was also observed at Cheetham Hill, by Mr. Baxendell, and at Heidelberg, by Dr. Wolkoff; indeed, at this latter station, it was found on several occasions that whilst the sun was shining brightly, it was totally devoid of chemical rays, the interposition of the small disc producing no diminution in the chemical action.

---

* 'Pogg. Ann.,' vol. lxxxviii. p. 363.

† "On the Colour of Steam under certain Circumstances, and on the Colours of the Atmosphere:" 'Edin. Transactions,' xiv. p. 371; 'Phil. Mag.,' xiv. xv. 3rd Series.

Thus, at altitudes from 0° 34′ to 12° 58′ on the following occasions, the sunlight was robbed entirely of its chemically active rays by passage through the atmosphere.

Altitude.	Direct Sun.	Diffuse Light.
0° 34′	0·000	0·026
1 32	0·000	0·024
2 29	0·000	0·038
3 27	0·000	0·028
6 0	0·000	0·030
10 40	0·000	0·073
11 51	0·000	0·079
12 58	0·000	0·080

The same inactive condition of the sun at low altitudes has frequently been observed at Kew, Cheetham Hill, and Owens College.

The following numbers give the results of an extended series of observations made at Heidelberg, by Dr. Wolkoff, at Kew by Mr. Baker, at Cheetham Hill by Mr. Baxendell, at Owens College by myself, and at Pará (Brazils) by Mr. T. E. Thorpe

The last column gives the ratio of chemical intensity of sun to sky, the fraction of the action of the diffuse light which the direct sun exerts. Thus, the ratio 0·106 at Owens College means that if 1 represents the intensity of the chemical light from the diffused light of the whole sky, 0·106 was the intensity of the ray emanated directly from the sun.

Results of Observations at Heidelberg.

	Number of Observations.	Range of Altitude of Sun.	Mean Altitude of Sun.	Intensity of Sky or diffused Daylight.	Intensity of direct Sunlight.	Ratio of Sun to Sky.
Group 1	10	0° to 15°	7° 15′	·048	·002	0·041
„ 2	19	15 — 30	24 43	·134	·066	0·472
„ 3	31	30 — 45	34 34	·170	·136	0·800
„ 4	22	45 — 60	53 37	·174	·263	1·511
„ 5	17	above 60	62 30	·199	·319	1·603

Results of Observations at Cheetham Hill.

	Number of Observations.		Mean Altitude of Sun.	Intensity of Sky or diffused Daylight.	Intensity of direct Sunlight.	Ratio of Sun to Sky.
	Sky.	Sun.				
Group 1	23	24	19° 30′	·064	·012	0·187
„ 2	22	22	25 31	·091	·019	0·208
„ 3	18	17	34 8	·104	·026	0·250

Results of Observations at Owens College.

	Number of Observations.		Mean Altitude of Sun.	Intensity of Sky or diffused Daylight.	Intensity of direct Sunlight.	Ratio of Sun to Sky.
	Sky.	Sun.				
Group 1	33	34	17° 8′	·066	·007	0·106
„ 2	20	24	26 38	·074	·008	0·108
„ 3	4	5	54 12	·140	·043	0·308

Results of Observations at Kew.

	Number of Observations.		Mean Altitude of Sun.	Intensity of Sky or diffused Daylight.	Intensity of direct Sunlight.	Ratio of Sun to Sky.
	Sky.	Sun.				
Group 1	18	18	12° 55′	0·065	0·014	0·213
„ 2	8	8	21 8	0·072	0·030	0·416
„ 3	7	7	28 16	0·104	0·056	0·538
„ 4	6	6	41 23	0·135	0·107	0·792

Results of Observations at Pará (Brazils).

	Number of Observations.		Mean Altitude of Sun.	Insensity of Sky or diffused Daylight.	Intensity of Direct Sunlight.	Ratio of Sun to Sky.
	Sky.	Sun.				
Group 1	20	20	42° 21′	·451	·168	·372
„ 2	25	25	62 49	·552	·277	·501
„ 3	25	25	77 20	·660	·267	·404

If we compare the numbers thus obtained by experiment with those calculated by Clausius on the theory of hollow vesicles impeding the passage of the rays, we shall notice a most remarkable difference between the experimental and calculated numbers.

Ratio of Chemical Intensities of direct Sunlight to diffused Light.

Sun's Altitude.	Calculated (Clausius).	Experiments.			
		Heidelberg.	Cheetham Hill.	Owens College.	Kew.
20°	0·491	0·350	0·19	0·10	0·36
25	0·896	0·480	0·20	0·11	0·47
30	1·320	0·650	0·23		0·57
35	1·690	0·820	0·26		0·65
40	2·032	1·00	—		0·75
50	2·634	1·37	—		
60	3·129	1·60	—		

Thus, whilst the theory requires that at an elevation of 20° the relation of diffuse light to sunlight was as 100 to 49·1, the experiments at Heidelberg showed a relation of 100 to 35, those of Kew of 100 to 30, at Cheetham Hill of 100 to 19, and at Owens College of 100 to 10, whilst the differences at higher altitudes becomes still greater. The Heidelberg observations were made on the summit of the Königstuhl, at an elevation of nearly 2000 feet above the sea level, and therefore at a position beneath which a very considerable portion of the densest air was situated; when the sun attained an altitude of 40°, the direct sun's rays exert the same amount of chemical action as the diffused light of a cloudless sky. At Kew Observatory, this point of equality is not nearly reached when the altitude of the sun is 42°. At Pará, under the equator, this difference between the chemical intensity of direct and diffuse sunlight becomes even more striking, for with an altitude of 77° the ratio of direct to diffuse is less than 0·5; that is, if 100 rays come from the diffused daylight only 50 come from the direct sunlight. This is certainly a very remarkable result. We thus see that the high tropical light curves are mainly caused, not by the increase of the chemically active rays in the direct sunlight, but by the enormous increase in the chemical activity of the diffuse light. It must, however, be borne in mind, that in the Pará observations the sky was not cloudless, and much light is reflected from the heavy cumuli; it is, nevertheless, remarkable, that under a tropical sun at an altitude of 80°, the diffuse daylight should exert a chemical action twice as great as the direct sunlight.

That the relation between the chemically active constituents of sunlight, direct and diffused, is quite different from the relation of the visible rays, can be easily ascertained. In some of the experiments made at Cheetham Hill, the shadow of a small disc was thrown on a horizontal surface of white paper, and careful estimations made of the relative brightness of the shaded and unshaded portions of the surface. A comparison of these results with those obtained at the same time for the chemical rays showed that when the sun's mean altitude was 25° 16′, the mean ratio of the chemical intensities of direct and diffuse light was 0·23 (or for 100 of diffuse light there was 23 of direct sunlight), whilst the ratio of the visible intensities was 4·0 (or for 100 of diffuse light there was 400 of direct sunlight). This shows that the action of the atmosphere was 1·74 times greater on the chemical than on the visible rays. Again, at Owens College, with a mean altitude of 12° 3′, the ratio of chemical intensity was 0·053, that of the visible intensity being 1·4; or the action of the atmosphere was 26·4 times as great upon the chemical as upon the visible rays.

How can we seek to explain this unexpected result—that the sun shining brightly, and casting a dark shadow, should at a height of 20° be capable of producing a chemical action of only $\frac{1}{10}$th of that produced by the diffuse light from the whole of a cloudless sky?

The explanation may be rendered plain by an experiment. Let us take a very slightly milky liquid—such as water containing $\frac{1}{10}$th grain of suspended sulphur in the gallon. So slight is the opalescence that we can scarcely detect it. Nevertheless, this minute trace of most finely-divided sulphur is sufficient to cut off the chemically active rays; the bright flash of carbonic disulphide in nitric oxide cannot explode the bulb when the opalescent solution is placed between it and the bulb; but the bulb explodes instantly when the light is allowed to pass through pure water.

We have here an exact imitation of the condition of the atmosphere as regards the chemically active rays. We see that light of a high degree of refrangibility cannot pass through the water containing the finely-divided sulphur; it is reflected back again by the particles of sulphur. So, too, the atmosphere is filled with particles which reflect the blue rays and transmit the red. What the exact nature of these particles may be, it is hard to say. We know, however, that the air is always filled with minute solid bodies. We see that in the sporules which are constantly present and cause fermentation and putrefactive decomposition. We see it also in the fact that particles of soda can always be detected in the atmosphere by spectrum-analysis. We notice these particles as motes dancing in the sunbeam, or in those grander paths of light which sometimes shoot up into the sky from a setting sun. The phenomenon may, perhaps, be caused by that finely-divided extra-terrestrial meteoric dust, which is, according to many physicists, constantly falling through the atmosphere to the earth's surface. These solid particles in the air *may* produce the above effects, and certainly do produce them; but we must remember that small particles of water are also able to transmit only red rays, and that, as Forbes has shown, the glorious ruddy tints of the setting sun are doubtless partly caused by aqueous vapour.

If the white beam of the electric lamp be passed through a tube 3 feet long, fitted with glass plates at each end, and filled with a scarcely visibly opalescent liquid, all the blue, green, and yellow rays will be completely cut off, and the immerging beam of light is deep red. Here indeed we have an artificial sunset. The finely divided sulphur reflects blue light and transmits red. If the visible light is diminished to one-third by means of opalescent sulphur, the chemically active rays are altogether cut off. The variation in the amount of this finely-divided matter, whether solid or liquid, in the air, will naturally produce variation in the tints of sunrise and sunset, and the presence at sunset of more aqueous vapour on the point of being condensed than at sunrise will explain the greater depth of colour in the setting than in the rising sun; the tints of dawn being, according to Mr. Brayley, those of evening in the reverse order.

In opal glass we have perhaps a still better illustration of the action of the atmosphere upon the chemically active rays. The opalescence of the glass is caused by the presence of very minute particles of bone-ash (calcium phosphate), or of arsenic trioxide, which are disseminated throughout the mass. By reflected light this glass appears white or blueish-white, by transmitted light it appears orange. If we place a bright source of white light behind the glass, we see that the direct rays are red, whilst the general diffused light reflected from the particles of the finely-divided matter in the glass is blueish-white.

That the size of the particles between which the light passes modifies the character of the transmitted ray scarcely admits of doubt.

This is most clearly exemplified in the beautiful phenomena of blue and ruby gold investigated by Mr. Faraday. Gold in thin plates reflects yellow, and transmits green light; but when suspended in a very fine state of division in water, it transmits blue, purple, or ruby light, according to the state of division in which it is precipitated.

The blue, purple, and ruby solutions all contain metallic gold in suspension, as Mr. Faraday has most conclusively shown, and yet they transmit totally different rays.

Hence we may fairly suppose that the varying size of the reflecting particles may aid in producing the widely differing sunset tints, from deep ruby-red to yellow and even *blue;* for we are not without several well-authenticated cases in which the sun has been seen to be *blue.* Thus, in the year 1831, a blue sun was noticed over a great part of Europe, as also in America.

We have seen that the light transmitted by finely-divided sulphur is red—it is, however, singular that blue sulphur can be formed. If we add ferric chloride to solution of sulphuretted hydrogen, we get a transient but very splendid purple tint; and we may ask ourselves whether this can be due to the size of the particle. If we heat sulphuretted hydrogen water up to 200° C. the gas decomposes, sulphur being deposited, and the solution attains a deep blue colour. Can this possibly be due to the minute division, almost approaching solution, which the sulphur attains? We find that on cooling the colour disappears, sulphur is deposited, and the liquid becomes milky. If we dissolve sulphur in sulphuric trioxide (anhydrous sulphuric acid), no chemical action that we know of occurs, and we get a magnificent deep-blue colour. Can this again be due to the minute division of the sulphur, thus permitting the blue rays alone to pass?

Finally, it is interesting to learn that both the analogues of sulphur, selenium and tellurium, yield magnificently coloured liquids when acted upon by sulphuric trioxide. Selenium in this state yields a deep olive-green solution, and tellurium a magnificent ruby-red colour.

Can these colours likewise be caused by the reflection or absorption of one kind of light and the preferential transmission of another kind by finely-divided particles?

The ruby-red gold liquid and ruby-red gold glass are both as transparent, and the one is apparently as truly a liquid as the red solution of tellurium. Yet we know that finely suspended metallic gold is the cause of this red tint. Are we acting contrary to analogy in supposing that the colour of this red liquid is caused by the particles of finely-divided tellurium, or that of these blue and green liquids by the particles of sulphur and selenium?

The speaker felt that he was here entering upon debateable ground, that, namely, of the cause of the colour of natural bodies; it was with much diffidence that he brought forward these examples of coloured solutions, and he did so only because they forced themselves on to his notice in the consideration of the plainer and now somewhat better understood phenomenon of the Opalescence of the Atmosphere.

[H. E. R.]

GENERAL MONTHLY MEETING,

Monday, June 4, 1866.

William Pole, Esq. M.A. F.R.S. in the Chair.

Edward Beanes, Esq. C.E. F.C.S.
Robert C. L. Bevan, Esq.

were *elected* Members of the Royal Institution.

John Hogg, M.D.

was *admitted* a Member of the Royal Institution.

The Special Thanks of the Members were returned to Sir Henry Holland, Bart. the President, for his Eighth Annual Donation of £40 to "the Donation Fund for the Promotion of Experimental Researches" (*see* page 151).

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same, viz.:—

FROM
Asiatic Society, Royal—Journal, Vol. II. Part 1. 8vo. 1866.
Astronomical Society, Royal—Monthly Notices, 1865–6. No. 6. 8vo.
British Architects' Institute, Royal—Sessional Papers, 1865–6. Part III. No. 1. 4to.
Editors—Artizan for May, 1866. 4to.
  Athenæum for May, 1866. 4to.
  British Journal of Photography for May, 1866. 4to.
  Chemical News for May, 1866. 4to.
  Engineer for May, 1866. fol.
  Horological Journal for May, 1866. 8vo.
  Journal of Gas-Lighting for May, 1866. 4to.
  Mechanics' Magazine for May, 1866. 8vo.
  Pharmaceutical Journal for May, 1866.
  Practical Mechanics' Journal for May, 1866. 4to.
Franklin Institute—Journal, Nos. 480, 481, 442, 483. 8vo. 1866.
Geographical Society, Royal—Proceedings, Vol. X. No. 3. 8vo. 1866.
Geological Society—Quarterly Journal, No. 86. 8vo. 1866.
Horticultural Society, Royal—Proceedings, 1866. No. 4. 8vo.
Jones, H. Bence, M.D. F.R.S. Hon. Sec. R.I.—Third Report of the Cattle Plague Commissioners. fol. 1866.
Leeds Literary and Philosophical Society—Annual Report, 1864–5. 8vo.
  Catalogue of the Library. 8vo. 1866.
Macpherson, John, M.D. M.R.I. (*the Author*)—Cholera in its Home. 8vo. 1866.
Mechanical Engineers' Institution, Birmingham—Proceedings, August, 1865. Part 3. 8vo.
Meteorological Society—Proceedings, No. 24. 8vo. 1866.
Photographic Society—Journal, No. 169. 8vo. 1866.
Royal Society of London—Proceedings, Nos. 82, 83. 8vo. 1866.
Sidney, Rev. Edwin, M.A.—Constantinus, R.: Lexicon Græco-Latinum. fol. 1592.
United Service Institution, Royal—Journal, Appendix to Vol. IX. 8vo. 1865.

Vereins zur Beförderung des Gewerbsfleisses in Preussen—Verhandlungen, Sept.-Dez. 1865. 4to.
Wilson and Beadell, Messrs.—Portrait of Sir Heny Holland, M.D. D.C.L. F.R.S. President R.I. 1866.
Yorkshire Geological and Polytechnic Society—Report for 1864-5. 8vo. 1866.

WEEKLY EVENING MEETING,

Friday, June 8, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President,
in the Chair,

Edward Frankland, Ph.D. F.R.S.
PROFESSOR OF CHEMISTRY, R.I.

On the Source of Muscular Power.

What is the source of muscular power? Twenty years ago, if this question had been asked, there were but few philosophers who would have hesitated to reply, "The source of muscular power is that peculiar force which is developed by living animals, and which we term the *vital force!*" but the progress of scientific discovery has rendered the view implied in such an answer so utterly untenable that, at the present moment, no one possessing any knowledge of physical science would venture to return such a reply. We now know that an animal, however high its organization may be, can no more *generate* an amount of force capable of moving a grain of sand, than a stone can fall upwards or a locomotive drive a train without fuel. All that such an animal can do is to liberate that store of force, or *potential energy*, which is locked up in its food. It is the *chemical change* which food suffers in the body of an animal that liberates the previously pent-up forces of that food, which now make their appearance in the form of *actual energy*—as heat and mechanical motion.

From food, and food alone, comes the *matter* of which the animal body is built up; and from food alone come all the different kinds of *physical force* which an animal is capable of manifesting.

The two chief forms of force thus manifested are *Heat* and *Muscular motion* or *mechanical work*, and these have been almost universally traced to two distinct sources—the *heat* to the oxidation of the *food*, and the *mechanical work* to the oxidation of the *muscles*.

This doctrine, first promulgated, the speaker believed, by Liebig, occupies a prominent position in that philosopher's justly celebrated 'Chemico-Physiological Essays.'

In his work entitled 'Die organische Chemie in ihrer Anwendung auf Physiologie und Pathologie, Braunschweig, 1842,' Liebig says, "All experience teaches that there is only one source of mechanical

GENERAL MONTHLY MEETING

Monday, June 4, 1866.

WILLIAM POLE, Esq. M.A. F.R.S. in th

Edward Beanes, Esq. C.E. F.C.S
Robert C. L. Bevan, Esq.

were *elected* Members of the Royal Institution.

John Hogg, M.D.

was *admitted* a Member of the Royal Institution.

The Special Thanks of the Members were ret
Holland, Bart. the President, for his Eighth An
£40 to "the Donation Fund for the Promotion
Researches" (*see* page 151).

The **PRESENTS** received since the last Meeti
table, and the thanks of the Members returned for

FROM

Asiatic Society, Royal—Journal, Vol. II. Part 1. 8vo.
Astronomical Society, Royal—Monthly Notices, 1865–6
British Architects' Institute, Royal—Sessional Papers, 1865
Editors—Artizan for May, 1866. 4to.
  Athenæum for May, 1866. 4to.
  British Journal of Photography for May, 1866. 4to.
  Chemical News for May, 1866. 4to.
  Engineer for May, 1866. fol.
  Horological Journal for May, 1866. 8vo.
  Journal of Gas-Lighting for May, 1866. 4to.
  Mechanics' Magazine for May, 1866. 8vo.
  Pharmaceutical Journal for May, 1866.
  Practical Mechanics' Journal for May, 1866. 4to.
Franklin Institute—Journal, Nos. 480, 481, 482, 483.
Geographical Society, Royal—Proceedings, Vol. X. N
Geological Society—Quarterly Journal, No. 86. 8vo.
Horticultural Society, Royal—Proceedings, 1866.
Jones, H. Bence, M.D. F.R.S. Hon. Sec. R.I.—Third
  Commissioners. fol. 1866.
Leeds Literary and Philosophical Society—Annual Rep
  Catalogue of the Library. 8vo. 1866.
Macpherson, John, M.D. M.R.I. (*the Author*)—Chol
Mechanical Engineers' Institution, Birmingham—Proc
  8vo.
Meteorological Society—Proceedings, No. 24. 8vo.
Photographic Society—Journal, No. 169. 8vo. 1866.
Royal Society of London—Proceedings, Nos. 82, 83.
Sidney, Rev. Edwin, M.A.—Constantinus, R.: Lexi
United Service Institution, Royal—Journal, Appendi

R. Mayer wrote,[*] "A muscle is only an apparatus by means of which the transformation of force is effected, *but it is not the material by the chemical change of which* mechanical work is produced." He showed that the 15 lbs. of dry muscles of a man weighing 150 lbs. would, if their mechanical work were due to their chemical change, be completely oxidized in 80 days, the heart itself in 8 days, and the ventricles of the heart in 2¼ days. After endeavouring to prove by physiological arguments that not one per cent. of the oxygen absorbed in the lungs could possibly come into contact with the substance of the muscles, Mayer says, "The fire-place in which this combustion goes on is the interior of the blood-vessels, the *blood* however—a slowly-burning liquid—is the oil in the flame of life. . . . Just as a plant-leaf transforms a given mechanical effect, *light*, into another force, *chemical difference*, so does the muscle produce mechanical work at the cost of the chemical difference consumed in its capillaries. Heat can neither replace the sun's rays for the plant, nor the chemical process in the animal: every act of motion in an animal is attended by the consumption of oxygen and the production of carbonic acid and water; every muscle to which atmospheric oxygen does not gain access ceases to perform its functions."

But Mayer was not the first to conceive this view of muscular action. Nearly 200 years ago, a Bath physician, Dr. John Mayow,[†] distinctly stated that for the production of muscular motion two things are necessary—the conveyance of combustible substances to the muscle by the blood, and the access of oxygen by respiration. He concluded that the chief combustible substance so used was fat. A century before Priestley isolated oxygen, Mayow was aware of its existence in the air, in nitre, and in nitric acid; he knew that combustion is supported by the oxygen of the air, and that this gas is absorbed in the lungs by the blood, and is absolutely necessary for muscular activity.

For two decades this doctrine sank into oblivion; and it is only within the last two years that it has been again advanced, chiefly by Haidenhain,[‡] Traube, and, to a limited extent, by Donders.[‖]

Experimental evidence was, however, still wanting to give permanent vitality to the resuscitated doctrine; for although the laborious and remarkable investigations of Voit[§] and of Edward Smith[¶] point unmistakably in the direction of Mayow and Mayer's hypothesis, yet the results of these physiologists were not sufficiently conclusive to render the opposite view untenable. This want of data of a sufficiently conclusive character has been supplied by a happily conceived experiment undertaken by Fick and Wislicenus in the autumn of last year, and described in the 'Philosophical Magazine,' vol. xxxi. p. 485. In the application of these data, however, to the problem now under consideration, one important link was found to be wanting, *viz.* the amount of actual energy generated by the oxidation of a given weight of muscle in the human body. Fick and Wislicenus refer to this missing link in the following words:—"The question now arises what quantity of heat is generated when muscle is burnt to the products in which its constituent elements leave the human body through the lungs and kidneys? At present, unfortunately, there are not the experimental data required to give an accurate answer to this important question, for neither the heat of combustion of muscle nor of the nitrogenous *residue* (urea) of muscle is known." Owing to the want of these data, the numerical results of the experiment of Fick and Wislicenus are rendered less conclusive against the hypothesis of muscle combustion than they otherwise would have been, whilst similar determinations, which have been made by Edward Smith, Haughton, Playfair, and others, are even liable to a total misinterpretation from the same cause.

---

[*] 'Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel,' 1845.

[†] 'De Motu musculari,' 1681. Mayow was born in 1645, and died 1679.

[‡] 'Mechanische Leistung Wärmeentwickelung und Stoffumsatz bei der Muskelthätigkeit,' 1864.

[‖] As this is passing through the press, the speaker has become aware that Messrs. Lawes and Gilbert advocated this doctrine in 1852, and repeatedly since; their opinions being founded upon experiments on the feeding of cattle.

[§] 'Untersuchungen uber den Einfluss des Kochsalzes, des Kaffeés und der Muskel-bewegungen auf den Stoffwechsel,' p. 150. Munich, 1860.

[¶] 'Phil Trans.,' 1861, p. 747.

The speaker stated that he had supplied this want by the calorimetrical determination of the actual energy evolved by the combustion of muscle and of urea in oxygen. Availing himself of these data he then proceeded to the consideration of the problem to be solved, the present condition of which might be thus summed up:—It is agreed on all hands that muscular power is derived exclusively from the mutual chemical action of the food and atmospheric oxygen; but opinions differ as to whether that food must first be converted into the actual organized substance of the muscle, before its oxidation can give rise to mechanical force, or whether it is not also possible that muscular work may be derived from the oxidation of the food, which has only arrived at the condition of blood and not of organized muscular tissue.

The importance of this problem can scarcely be overrated; it is a corner-stone of the physiological edifice, and the key to the phenomena of the nutrition of animals. For its satisfactory solution the following data require to be determined:—

1st. The amount of force or actual energy generated by the oxidation of a given amount of muscle in the body.

2nd. The amount of mechanical force exerted by the muscles of the body during a given time.

3rd. The quantity of muscle oxidized in the body during the same time.

If the total amount of force involved in muscular action, as measured by the mechanical work performed, be greater than that which could possibly be generated by the quantity of muscle oxidized during the same time, it necessarily follows that the power of the muscles is not derived *exclusively* from the oxidation of their own substance.

As regards the first datum to be determined, it is necessary to agree upon some unit for the measurement of mechanical force. The unit most commonly adopted is that represented by the lifting of a kilogram weight to the height of one metre. The researches of Joule and Mayer have connected this standard unit with heat;—they prove that the force required to elevate this weight 425 times will, when converted into heat, raise the temperature of an equal weight of water 1° C. If this weight were let fall from a height of 425 metres, its collision with the earth would produce an amount of heat sufficient to raise the temperature of 1 kilogram of water 1° C. The same heating effect would also of course be produced by the fall of 425 kilograms through 1 metre. This standard of force is termed a *metrekilogram*;* and 425 metrekilograms are equal to that amount of heat which is necessary to raise the temperature of 1 kilogram of water through 1° C. If then it be found that the heat evolved by the combustion of a certain weight of charcoal or muscle, for instance, raises the temperature of 1 kilogram of water through 1° C., this means, when translated into mechanical power, 425 metrekilograms. Again, if a man weighing 64 kilograms climbs to a height of 1,000 metres, the ascent of his body to this height represents 64,000 metrekilograms of work; that is, the labour necessary to raise a kilogram weight to the height of 1 metre 64,000 times.

In order to estimate the amount of actual energy generated by the oxidation of a given amount of muscle in the body, it is necessary to determine, first, the amount of actual energy generated by the combustion of that amount of muscle in oxygen, and then to deduct from the number thus obtained the amount of energy still remaining in the products of the oxidation of this quantity of muscle which leave the body. Of these products, urea and uric and hippuric acids are the only ones in appreciable quantity which still retain potential energy on leaving the body, and of these the two latter are excreted in such small proportions that they may be considered as urea without introducing any material error into the results.

These determinations were made in Lewis Thompson's calorimeter, which consists of a copper tube to contain a mixture of chlorate of potash with the combustible substance, and which can be enclosed in a kind of diving-bell, also of copper, and so lowered to the bottom of a suitable vessel containing a known quantity (2 litres) of water. The determinations were made with this instrument in the following manner:—19·5 grams of chlorate of potash, to which about ⅛th of peroxide of manganese was added was intimately mixed with a known weight (generally about 2 grams) of the substance whose potential energy was to be determined, and the mixture being then placed in the copper tube above mentioned, a small piece of cotton thread previously steeped in chlorate of potash and dried was inserted in the mixture. The temperature of the water in the calorimeter was now carefully ascertained by a delicate thermometer; and the end of the cotton thread being ignited the tube with its contents was placed in the copper bell and lowered to the bottom of the water. As soon as the combustion reached the mixture a stream of gases issued from numerous small openings at the lower edge of the bell and rose to the surface of the water—a height of about 10 inches.

---

* I follow the example of the Registrar-General in abbreviating the French word *gramme* to gram.

At the termination of the deflagration, the water was allowed free access to the interior of the bell, by opening a stopcock connected with the bell by a small tube rising above the surface of the water in the calorimeter. The gases in the interior of the bell were thus displaced by the incumbent column of water, and by moving the bell up and down repeatedly a perfect equilibrium of temperature throughout the entire mass of water was quickly established. The temperature of the water was again carefully observed, and the difference between this and the previous observation determines the calorific power or potential energy, expressed as heat, of the substance consumed.

The value thus obtained is, however, obviously subject to the following corrections:—

1. The amount of heat absorbed by the calorimeter and apparatus employed, *to be added.*

2. The amount of heat carried away by the escaping gases, after issuing from the water, *to be added.*

3. The amount of heat due to the decomposition of the chlorate of potash employed, *to be deducted.*

4. The amount of heat equivalent to the work performed by the gases generated in overcoming the pressure of the atmosphere, *to be added.*

Although the errors due to these causes to some extent neutralize each other, there is still an outstanding balance of sufficient importance to require that the necessary corrections should be carefully attended to.

The amount of error from the first cause was once for all experimentally determined, and was added to the increase of temperature observed in each experiment.

The amount of heat carried away by the escaping gases after issuing from the water may be divided into two items, *viz.*:—

a. The amount of heat rendered latent by the water which is carried off by the gases in the form of vapour.

b. The amount of heat carried off by these gases by reason of their temperature being above that of the water from which they issue.

It was ascertained that a stream of dry air when passed through the water of the calorimeter, at about the same rate and for the same period of time as the gaseous products of combustion, depressed the temperature of the water by only $0^{\circ}\cdot02$ C.

By placing a delicate thermometer in the escaping gases, and another in the water, no appreciable difference of temperature could be observed. Both these items may therefore be safely neglected.

The two remaining corrections can be best considered together, since a single careful determination eliminates both. When a combustible substance is burnt in gaseous oxygen, the conditions are essentially different from those which obtain when the same substance is consumed at the expense of the combined or solid oxygen of chlorate of potash. In the first case the products of combustion, when cooled to the temperature of the water in the calorimeter, occupy less space than the substances concerned in the combustion, and no part of the energy developed is therefore expended in external work, that is, in overcoming the pressure of the atmosphere. In the second case, both the combustible and the supporter of combustion are in the solid condition, whilst a considerable proportion of the products of combustion are gases. The generation of the latter cannot take place without the performance of external work, for every cubic inch produced must obviously, in overcoming atmospheric pressure, perform an amount of work equivalent, in round numbers, to the lifting of a weight of 15 lbs. to the height of one inch. In performing this work the gases are cooled, and consequently less heat is communicated to the water of the calorimeter. Nevertheless, the loss of heat due to this cause is but small. Under the actual conditions of the experiments detailed below, its amount would only have increased the temperature of the water in the calorimeter by $0^{\circ}\cdot07$ C. Even this slight error is entirely eliminated by the final correction which we have now to consider.

It is well known that the decomposition of chlorate of potash into chloride of potassium and free oxygen is attended with the evolution of heat. If a few grains of peroxide of manganese, or better, of peroxide of iron, be dropped into an ounce or two of fused chlorate of potash which is slowly disengaging oxygen, the evolution of gas immediately proceeds with great violence, and the mixture becomes visibly red hot, although the external application of heat be discontinued from the moment when the metallic peroxide is added. The latter remains unaltered at the close of the operation. It is thus obvious that chlorate of potash, on being decomposed, furnishes considerably more heat than that which is necessary to gasify the oxygen which it evolves. It was therefore necessary to determine the amount of heat thus evolved by the quantity of chlorate of potash (9·75 grams) mixed with one gram of the substance burnt in each of the following determinations. This was effected by the use of two copper tubes, the one placed within the other. The interior tube was charged with a known weight of the same mixture of chlorate of potash and peroxide of manganese as that used for the subsequent experiments, whilst the annular space between the two tubes was filled with a combustible mixture of chlorate and spermaceti, the calorific value of which had been previously ascertained. The

latter mixture was ignited in the calorimeter as before, and the heat generated during its combustion effected the complete decomposition of the chlorate in the interior cylinder, as was proved by a subsequent examination of the liquid in the calorimeter, which contained no traces of undecomposed chlorate. The following are the results of five experiments thus made, expressed in units of heat, the unit being equal to 1 gram of water raised through 1° C. of temperature:—

	Units of Heat.
1st experiment	340
2nd "	300
3rd "	375
4th "	438
5th "	438
	5)1891
Mean	378

This result was confirmed by the following experiments:—

1. Starch was burnt, firstly, in a current of oxygen gas, and secondly, by admixture with chlorate of potash and peroxide of manganese.

Heat units furnished by one gram of starch burnt with 9·75 grams chlorate of potash	4290
Heat units furnished by the same weight of starch burnt in a stream of oxygen gas	3964
Difference	326

2nd. Phenylic alcohol was burnt with chlorate of potash, and the result compared with the calorific value of this substance as determined by Favre and Silbermann.

Heat units furnished by one gram of phenylic alcohol burnt with 9·75 grams chlorate of potash	8183
Heat units furnished by one gram of phenylic alcohol when burnt with gaseous oxygen (Favre and Silbermann) .	7842
Difference	341

These three determinations of the heat evolved by the decomposition of 9·75 grams of chlorate of potash, furnishing the numbers 378, 326, and 341, agree as closely as could be expected, when it is considered that all experimental errors are necessarily thrown upon the calorific value of the chlorate of potash.

The mean of the above five experimental numbers was, in all cases, deducted from the actual values read off in the following determinations.

It was ascertained by numerous trials that all the chlorate of potash was decomposed in the deflagrations, and that but mere traces of carbonic oxide were produced.

Joule's mechanical equivalent of heat was employed, viz. 1 kilogram of water raised 1° C. = 423 metrekilograms.

The following results were obtained:

Actual energy developed by one gram of each substance when burnt in oxygen.

Name of Substance dried at 100° C.	HEAT UNITS.					Metre-kilograms of force. (Mean.)
	1st Experiment.	2nd Experiment.	3rd Experiment.	4th Experiment.	Mean.	
Beef Muscle purified by repeated washing with ether . . .	5174	5062	5195	5088	5103	2161
Purified Albumen . .	5009	4987	..	..	4998	2117
Beef Fat	9069	..	..	..	9069	3841
Hippuric Acid . . .	5330	5437	..	..	5383	2280
Uric Acid	2645	2585	..	..	2615	1108
Urea*	2121	2302	2207	2197	2206	934

It is evident that the above determination of the actual energy developed by the combustion of muscle in oxygen represents more than the amount of actual energy produced by the oxidation of muscle within the body, because, when muscle burns in oxygen its carbon is converted into carbonic acid, and its hydrogen into water; the nitrogen being, to a great extent, evolved in the elementary state; whereas, when muscle is most completely consumed in the body, the products are carbonic acid water and urea; the whole of the nitrogen passes out of the body as urea—a substance which still retains a considerable amount of potential energy. Dry muscle and pure albumen yield, under these circumstances, almost exactly one-third of their weight of urea, and this fact, together with the above determination of the actual energy developed on the combustion of urea, enables us to deduce with certainty the amount of actual energy developed by muscle and albumen respectively when consumed in the human body. It is as follows:—

Actual energy developed by one gram of each substance when consumed in the body.

Name of substance dried at 100° C.	Heat units. (Mean.)	Metrekilograms of force. (Mean.)
Beef Muscle purified by ether . .	4368	1848
Purified Albumen	4263	1803

---

* The speaker showed the combustibility of urea by burning it upon asbestos in a jar of oxygen gas.

We have thus ascertained the first of our three data, *viz.* the amount of force or actual energy generated by the oxidation of a given amount of muscle in the body; and we now proceed to ascertain the second, *viz.* the amount of mechanical force exerted by the muscles of the body during a given time. For this purpose we have only to avail ourselves of the details of Fick and Wislicenus's conclusive experiment already referred to, and which consisted in the ascent of the Faulhorn in Switzerland from the lake of Brienz. This mountain can be ascended by a very steep path from Iseltwald, which was of course favourable for the experiment, and there is an hotel on the summit which allowed the experimenters to pass the following night under tolerably normal circumstances. The following is their own description and estimate of the amount of work performed in the ascent.*

"Let us now inquire how much work was really done by our muscles. One item necessary for the reply is already at hand, *viz.* the height of the summit of the Faulhorn above the level of the lake of Brienz multiplied by the weight of the body; the former reckoned in metres, the latter in kilograms. The weight of the body with the equipments (hat, clothes, stick) amounted to 66 kilograms in Fick's case, and 76 in Wislicenus's. The height of the Faulhorn above the level of the lake of Brienz is, according to trigonometric measurements, exactly 1956 metres. Therefore Fick performed 129,096 and Wislicenus 148,656 metrekilograms of muscular work."

But in addition to this measurable external work there is another item of force "which can be expressed in units of work; and though its value cannot be quite accurately calculated, yet a tolerable approximation can be made. It consists of the force consumed in respiration and the heart's action. The work performed by the heart has been estimated, in a healthy full-grown man, at about 0·64 metrekilogram† for each systole. During the ascent, Fick's pulse was about 120 per minute. That gives for the 5·5 hours of the ascent an amount of work which may be estimated at 25,344 metrekilograms, entirely employed in the maintenance of the circulation. No attempt has yet been made to estimate the labour of respiration. One of us has shown, however, in the second edition of his 'Medical Physics' (p. 206), that Donders' well-known investigations concerning the conditions of pressure in the cavity of the thorax give sufficient data for such an estimate. He has there shown that the amount of work performed in an inspiration of 600 cubic centims. may be rated at about 0·63 metrekilogram. Fick breathed during the ascent at an average rate of about 25 respirations per minute, which gives, according to this estimation, an amount of respiratory work for the whole ascent of 5197 metrekilograms. If we add this, and the number representing the work of the heart, to the external work performed by Fick, we obtain a total of 159,637 metrekilograms. If we suppose that Wislicenus's respiratory and circulatory work bore the same proportion to Fick's as his bodily weight did to Fick's, *i. e.* 7 : 6, we obtain for Wislicenus's amount of work, as far as it is possible to calculate it, a total of 184,287 metrekilograms.

---

* 'Phil. Mag.' vol. xxxi. p. 496, 1866.

† 0·43 is here assigned as the work of the left, and 0·21 as that of the right ventricle.

"Besides these estimated (and certainly not over-estimated) items, there are several others which cannot be even approximately calculated, but the sum of which, if it could be obtained, would probably exceed even our present large total. We will try to give at least some sort of an account of them. It must first be remembered that in the steepest mountain path there are occasional level portions, or even descents. In traversing such places the muscles of the leg are exerted as they are in ascending, but the whole work performed is transformed back into heat. The same force-producing process, however, must be going on in the muscles as if work were being performed which did not undergo this transformation. In order to make this point yet clearer we may take into consideration that the whole work of the ascent, only existed temporarily as work. On the following day the result was reversed; our bodies approached the centre of the earth by as much as they had receded from it the day before, and, in consequence, on the second day an amount of heat was liberated equal to the amount of work previously performed. The two parts of the action, which in this case were performed on two separate days, take place in walking on level ground in the space of a footstep.

"Let us observe, besides, that in an ascent it is not only those muscles of the leg specially devoted to climbing which are exerted, the arms, head, and trunk are continually in motion. For all these movements force-generating processes are necessary, the result of which cannot, however, figure in our total of work, but must appear entirely in the form of heat, since all the mechanical effects of these movements are immediately undone again. If we raise an arm, we immediately let it drop again, &c.

"There was besides a large portion of our muscular system employed during the ascent, which was performing no external work (not even temporary work, or mechanical effects immediately reversed), but which cannot be employed without the same force-generating processes which render external work possible. As long as we hold the body in an upright position, individual groups of muscles (as, for instance, the muscles of the back, neck, &c.) must be maintained in a state of continual tetanus in order to prevent the body from collapsing. We may conceive of a tetanized muscle as holding up a weight which would immediately fall if the supply of actual energy were to cease. It is active but it performs no work, and therefore all the force produced is liberated in the form of heat."

Thus the total amount of measured and estimable work performed in 5·5 hours in the experiments before us was 159,637 metrekilograms for Fick, and 184,287 metrekilograms for Wislicenus. This is our second datum.

The third, *viz.* the amount of muscle oxidized in the body during the performance of this work has been carefully determined by the same experimenters, as well as the rate of muscle consumption before and after the ascent. For the details of these determinations the speaker referred his hearers to the 'Philosophical Magazine' for 1866, vol. xxxi. page 488; but the following is a condensed summary of the results:—

Ascent of the Faulhorn.

	Fick.	Wislicenus.
	Gram.	Gram.
Amount of Nitrogen secreted in Urine per hour before ascent	·63	·61
Weight of dry Muscle corresponding to Nitrogen	4·19	4·05
Amount of Nitrogen secreted per hour during ascent	·41	·39
Weight of dry Muscle corresponding to Nitrogen	2·70	2·56
Amount of Nitrogen secreted per hour during 6 hours after the ascent	·40	·40
Weight of dry Muscle corresponding to Nitrogen	2·63	2·63
Amount of Nitrogen secreted per hour during the following night	·45	·51
Weight of dry Muscle corresponding to Nitrogen	3·06	3·39
Total amount of Nitrogen secreted during ascent	3·31	3·13
Ditto during 6 hours after ascent	2·43	2·42
	5·74	5·55
Weight of dry Muscle corresponding to Nitrogen secreted: During ascent	20·98	20·89
Weight of dry Muscle corresponding to Nitrogen secreted: During 6 hours after ascent	16·19	16·11
	37·17	37·00

The results of these determinations add a new link to the chain of experimental evidence, that muscular exertion does not necessarily increase the excretion of nitrogen through the urine. From mid-day before the ascent (August 29th, 1865) to the following evening at seven o'clock (August 30th) both gentlemen abstained from all nitrogenous food. During these thirty-one hours they had nothing in the way of solid food except starch, fat, and sugar. The two former were taken in the form of cakes. Starch was made up with water into a thin paste, which was then made into small cakes and fried with plenty of fat. The sugar was taken dissolved in tea. In addition to this there was the sugar contained in the beer and wine, which were taken in quantities usual in mountain excursions. It was doubtless owing to this absence from food containing nitrogen that the amount of this element secreted through the urine, declined tolerably regularly from the 29th of August till the evening of the 30th. Even in the night of the 30th to the 31st, in spite of the plentiful meal of albuminous food on the evening of the 30th, the secretion of nitrogen was less than on the preceding night. The reason of this is probably to be sought for in the circumstance that during the period of abstinence, the secretion of nitrogen was carried on at the expense of tissues, and now these tissues required reparation.

It is perhaps scarcely worthy of record that during the ascent neither of the experimenters perspired perceptibly, since it has been proved by Ranke that no appreciable amount of nitrogen leaves the system in the matter of perspiration; and as Thiry has also shown that no nitrogen is got rid of by respiration, it follows that in addition to the nitrogen contained in the urine, the only other mode of exit for this element is through the fæces. Now the proportion secreted through the fæces has been estimated by Ranke at about one-twelfth of that in the urine; but inasmuch as all experiments on the subject tend to show that this alvine nitrogen is, as voided, a constituent of un-oxidized compounds, that is, of compounds that have not yielded up their force, it has no claim upon our attention.

There is still another circumstance which requires to be taken into consideration before we proceed to apply our three data to the solution of the problem before us. It is this:—Is it possible that at the termination of the ascent of the Faulhorn there might be a considerable quantity of the nitrogenous products of decomposition retained in the body? Considering the physiological effect of the retention of urea in the system, as exemplified whenever the secretion of urine is interrupted, it is difficult to imagine the possibility of any considerable quantity of urea being retained in the system of a healthy man. It is, however, otherwise with creatin, another of the products of the metamorphosis of tissue; for it has been repeatedly shown that a muscle which has been hard worked contains more creatin than one that has been at rest. Thus the quantity of creatin contained in the heart of an ox was found to be ·14 per cent. (Gregory), and that in other ox-flesh only ·06 per cent. (Staedeler). Now the muscles which extend the leg in walking, and which do the essential work in ascending, have been estimated by Weber to weigh in both legs 5·8 kilograms, and if we assume that before the ascent these muscles contained ·06 per cent. of creatin, whilst after the ascent the percentage had increased to ·14 per cent., then the amount of creatin thus exceptionally retained would amount to 4·64 grams, which would be derived from 8·4 grams of muscle.

The speaker had been unable to determine the calorific effect of creatin, and consequently the actual energy developed by the transformation of muscle into creatin; for, although he was kindly furnished with an ample supply of this material by Dr. Dittmar, yet all attempts to burn it in the calorimeter were fruitless. Even when mixed in very small proportions with chlorate of potash and other combustibles of known value, the mixture invariably exploded violently on ignition. Although actual determination thus fails us, there can be no doubt that the transformation of muscle into creatin and other non-nitrogenous products must be attended by the liberation of far less actual energy than its transformation into urea, carbonic acid, and water. To be convinced of this, it is only necessary to compare (under equal nitrogen value) the formulæ of muscle, creatin, and urea, remembering at the same time that the nitrogen probably possess no thermal value, and that each atom of oxygen destroys approximately the thermal effect of two atoms of hydrogen.

	Comparable formulæ.	Powerful or unburnt matter.
Muscle . . .	$C_{24} H_{37} N_6 O_7$	$C_{24} H_{23}$
Creatin . . .	$C_8 H_{18} N_6 O_4$	$C_8 H_{10}$
Urea . . .	$C_3 H_{12} N_6 O_3$	$C_3 H_6$

Thus it is evident that the amount of creatin exceptionally retained in the system could not greatly affect the result of the experiment as regards the possible amount of actual energy derivable from the metamorphosed tissues during the ascent; firstly, on account of the small quantity of creatin so retained, and, secondly, because creatin still contains about one-third of the potential energy of the muscle from which it is derived. But as this point cannot be experimentally demonstrated the speaker followed the example of Fick and Wislicenus, and made a very liberal allowance on this score. He allowed, as they had done, that the whole of the nitrogen secreted during the six hours after the ascent was exceptionally retained in the system *as urea* during the ascent. This is equivalent to an admission that the muscles of the legs contained at the end of the ascent eleven times as much creatin as was present in them before the ascent. In the above tabular statement of results provision has been made for this allowance by adding together, on the one hand, the amounts of nitrogen secreted during the ascent and six hours after it, and, on the other, the weights of dry muscle corresponding to these two amounts of nitrogen.

Having thus far cleared the ground, let us now compare the amount of measured and calculated work performed by each of the experimenters during the ascent of the Faulhorn, with the actual energy capable of being developed by the maximum amount of muscle that could have been consumed in their bodies, this amount being represented by the total quantity of nitrogen excreted in each case during the ascent and for six hours afterwards.

	Fick.	Wislicenus.
	Grams.	Grams.
Weight of dry Muscle consumed	37·17	37·00
	Metrekilograms.	Metrekilograms.
Actual energy capable of being produced by the consumption of 37·17 and 37·00 grams of dry Muscle in the body	68,690	68,376
Measured work performed in the ascent (external work)	129,096	148,656
Calculated circulatory and respiratory work performed during the ascent (internal work)	30,541	35,631
Total ascertainable work performed . . .	159,637	184,287

It is thus evident that the muscular power expended by these gentlemen in the ascent of the Faulhorn could not be exclusively derived from the oxidation, either of their muscles, or of other nitrogenous constituents of their bodies, since the maximum of power capable of being derived from this source even under very favourable assumptions is, in both cases, less than one-half of the work actually performed. But the deficiency becomes much greater if we take into consideration the fact, that the actual energy developed by oxidation or combustion cannot be wholly transformed into mechanical work. In the best constructed steam-engine for instance, only $\frac{1}{10}$th of the actual energy developed by the burning fuel can be obtained in the form of mechanical power; and in the case of man, Helmholtz estimates that not more than $\frac{1}{5}$th of the actual energy developed in the body can be made to appear as external work. The experiments of Haidenhain, however, show that, under favourable circumstances, a muscle may be made to yield in the shape of mechanical work as much as one-half of the actual energy developed within it, the remainder taking the form of heat. Taking then this highest estimate of the proportion of mechanical work capable of being got out of actual energy, it becomes necessary to multiply by 2 the above numbers representing the ascertainable work performed, in order to express the actual energy involved in the production of that work. We then get the following comparison of the actual energy capable of being developed by the amount of muscle consumed, with the actual energy necessary for the performance of the work executed in the ascent of the Faulhorn.

	Fick.	Wislicenus.
	Metrekilograms.	Metrekilograms
Actual energy capable of being produced by Muscle metamorphosis	68,690	68,376
Actual energy expended in work performed .	319,274	368,574

Thus, taking the average of the two experiments, it is evident that *scarcely ⅕th of the actual energy required for the work performed could be obtained from the amount of muscle consumed.*

Interpreted in the same way, previous experiments of a like kind prove the same thing, though not quite so conclusively. To illustrate this I will here give a summary of three sets of experiments: the first, made by Dr. E. Smith, upon prisoners engaged in treadmill labour; the second, by the Rev. Dr. Haughton, upon military prisoners engaged in shot drill; and the third, adduced by Playfair and made upon pedestrians, piledrivers, men turning a winch, and other labourers.

TREADWHEEL EXPERIMENTS.

A treadwheel is a revolving drum with steps placed at distances of 8 inches, and the prisoners are required to turn the wheel downwards by stepping upwards. Four prisoners, designated below as A, B, C, and D, were employed in these experiments, and each worked upon the wheel in alternate quarters of an hour, resting in a sitting posture during the intervening quarters. The period of actual daily labour was 3½ hours. The total ascent per hour 2160 feet, or per day 1·432 mile. The following are the results:—

Treadwheel Work.—(E. Smith.)

	Weight in Kilograms.	Ascent in Metres.	Days occupied in Ascent.	External work performed in Metrekilograms.	Total Nitrogen evolved.	Weight of dry Muscle corresponding to Nitrogen.
					Grams.	Grams.
A	47·6	23,045	10	1,096,942	171·3	1101·2
B	49	23,045	10	1,129,205	174·5	1121·7
C	55	20,741	9	1,140,755	168·0	1080·1
D	56	20,741	9	1,161,496	159·3	1024·3

In these experiments the measured work was performed in the short space of 3½ hours, whilst the nitrogen estimated was that voided in the shape of urea in 24 hours. It will, therefore, be necessary to add to the measured work, that calculated for respiration and circulation for the whole period of 24 hours. This amount of internal work was computed, from the estimates of Helmholtz and Fick, to be as follows:—

Internal Work.—(Helmholtz and Fick.)

	Work performed.	Actual energy required.
	Metrekilograms.	Metrekilograms.
Circulation of the blood during 24 hours, at 75 pulsations per minute	69,120*	138,240
Respiration for 24 hours, at 12 respirations per minute	10,886	21,772
Statical activity of muscles	not determined	not determined
Peristaltic motion	" "	" "
	80,006	160,012

Taking this estimate for internal work, the average results of the treadwheel experiments may be thus expressed :—

Treadwheel Work.

Average external work per man per day	119,605 mks.
Average nitrogen evolved per man per day	17·7 grams.
Weight of dry muscle corresponding to average nitrogen evolved per day	114 "
Actual energy producible by the consumption of 114 grams of dry muscle in the body	210,672 mks.
Average actual energy developed in the body of each man, *viz.*—	
External work . . . 119,605 × 2 = 239,210 mks.	
Circulation . . . 69,120 × 2 = 138,240 "	
Respiration . . . 10,886 × 2 = 21,772 "	
	399,222 "

In these experiments the conditions were obviously very unfavourable for the comparison of the amount of actual energy producible from muscle metamorphosis, with the quantity of actual energy expended in the performance of estimable work; since, during that portion of the twenty-four hours not occupied in the actual experiment, a large amount of unestimable internal work, such as the statical activity of the muscles, peristaltic motion, &c., was being performed. Nevertheless, these experiments show that the average actual energy developed in producing work in the body of each man was nearly twice as great as that which could possibly be produced by the whole of the nitrogenous matter oxidized in the body during 24 hours. It must also be remarked that the prisoners were fed upon a nitrogenous diet containing six ounces of cooked meat, without bone; a diet which, as is well known, would favour the production of urea.

---

* Since making use of this number, I find that Donders estimates the work of the heart alone, for 24 hours, at 86,000 metrekilograms, a figure which is higher than that above for the combined work of circulation and respiration.

SHOT-DRILL EXPERIMENTS.

The men employed for these experiments were fed exclusively upon vegetable diet, and they consequently secreted a considerably smaller amount of nitrogen than the flesh-eaters engaged in the treadwheel work. The other conditions were, however, equally unfavourable for showing the excess of work performed, over the amount derivable from muscle metamorphosis.

In shot-drill, each man lifts a 32 lb. shot from a tressel to his breast, a height of 3 feet; he then carries it a distance of 9 feet, and lays it down on a similar support, returning unloaded. Six of these double journeys occupy one minute. The men were daily engaged with—

Shot drill . . .	3 hours.
Ordinary drill . . .	1¼ "
Oakum picking . .	3½ "

The total average daily external work was estimated by Haughton at 96,316 metrekilograms per man.

The following is a condensed summary of the results of these experiments:—

Military Vegetarian Prisoners at Shot Drill.—(Haughton.)

Average external work per man per day		96,316 mks.
Average nitrogen evolved per man per day		12·1 grams
Weight of dry muscle corresponding to average nitrogen evolved per day		77·9 "
Actual energy producible by the consumption of 77·9 grams of dry muscle in the body		143,950 mks.
Average actual energy developed daily in the body of each man, *viz.* External work, 96,316 × 2 = ...	192,632 mks.	
Internal work	160,012 "	
		352,644 mks.

Owing chiefly to the vegetable diet of these prisoners, the result is more conclusive than that obtained upon the treadwheel, the amount of work actually performed being considerably more than twice as great as that which could possibly be obtained through the muscle metamorphosis occurring in the bodies of the prisoners.

PLAYFAIR'S DETERMINATIONS.

In these determinations the number 109,496 metrekilograms was obtained as the average amount of daily work performed by pedestrians, pile-drivers, porters, paviours, &c.; but, as the amount of muscle consumption is calculated from the nitrogen taken in the food, the conditions are as unfavourable as possible with regard to the point the speaker was seeking to establish; for it is here assumed, not only that all the nitrogen taken in the food enters the blood, but also that it is converted into muscle, and is afterwards oxidized to carbonic acid, water, and urea.

The following are the results expressed as in the previous cases:—

Hard-worked Labourer.—(Playfair.)

	Work performed.	Actual energy required.
Daily labour (external work)	109,496 mks.	218,992 mks.
Internal work	80,006 „	160,012 „
	189,502 mks.	379,004 mks.
Actual energy capable of being produced from 5·5 oz. (155·92 grms.) of flesh-formers contained in the daily food of the labourer .	..	288,140 mks.

Thus, even under the extremely unfavourable conditions of these determinations, the actual work performed exceeded that which could possibly be produced through the oxidation of the nitrogenous constituents of the daily food by more than 30 per cent.

We have seen, therefore, in the above four sets of experiments, interpreted by the data afforded by the combustion of muscle and urea in oxygen, that the transformation of tissue alone cannot account for more than a small fraction of the muscular power developed by animals; in fact, this transformation goes on at a rate almost entirely independent of the amount of muscular power developed. If the mechanical work of an animal be doubled or trebled there is no corresponding increase of nitrogen in the secretions; whilst it was proved on the other hand by Lawes and Gilbert, as early as the year 1854, that animals, under the same conditions as regarded exercise, had the amount of nitrogen in their secretions increased twofold by merely doubling the amount of nitrogen in their food. Whence then comes the muscular power of animals? What are the substances which, by their oxidation in the body, furnish the actual energy, whereof a part is converted into muscular work? In the light of the experimental results detailed above, can it be doubted that a large proportion of the muscular power developed in the bodies of animals has its origin in the oxidation of non-nitrogenous substances? For whilst the secretion of nitrogen remains nearly stationary under widely different degrees of muscular exertion, the production of carbonic acid increases most markedly with every augmentation of muscular work, as is shown by the following tabulated results of E. Smith's highly important experiments regarding the amount of carbonic acid evolved from his own lungs under different circumstances.*

---

* Phil. Trans. for 1859, p. 709.

Excretion of carbonic acid during rest and muscular exertion :—

	Carbonic acid per hour.
During sleep	19·0 grams.
Lying down and sleep approaching	23·0 „
In a sitting posture	29·0 „
Walking at rate of 2 miles per hour	70·5 „
„ „ 3 „ „	100·6 „
On the treadwheel, ascending at the rate of 28·65 feet per minute	189·6 „

It has been already stated as a proposition upon which all are agreed, that food, and food alone, is the ultimate source from which muscular power is derived; but the above determinations and considerations, the speaker believed, prove conclusively, firstly, that the non-nitrogenous constituents of the food, such as starch, fat, &c., are the chief sources of the actual energy, which becomes partially transformed into muscular work; and secondly, that the food does not require to become organized tissue before its metamorphosis can be rendered available for muscular power; its digestion and assimilation into the circulating fluid—the blood—being all that is necessary for this purpose. It is, however, by no means the non-nitrogenous portions of food alone that are capable of being so employed, the nitrogenous also, inasmuch as they are combustible, and consequently capable of furnishing actual energy, might be expected to be available for the same purpose, and such an expectation is confirmed by the experiments of Savory upon rats,* in which it is proved that these animals can live for weeks in good health upon food consisting almost exclusively of muscular fibre. Even supposing these rats to have performed no external work, nearly the whole of their internal muscular work must have had its source in the actual energy developed by the oxidation of their strictly nitrogenous food.

It can scarcely be doubted, however, that the chief use of the nitrogenous constituents of food is for the renewal of muscular tissue; the latter, like every other part of the body, requiring a continuous change of substance, whilst the chief function of the non-nitrogenous is to furnish by their oxidation the actual energy which is in part transmuted into muscular force.

The combustible food and oxygen coexist in the blood which courses through the muscle, but when the muscle is at rest there is no chemical action between them. A command is sent from the brain to the muscle, the nervous agent determines oxidation. The potential energy becomes active energy, one portion assuming the form of motion, another appearing as heat. *Here is the source of animal heat, here the origin of muscular power!* Like the piston and cylinder of a steam-engine, the muscle itself is only a machine for the transformation of heat into motion; both are subject to wear and tear and require renewal, but neither contributes in any important degree by its own oxidation to the actual production of the mechanical power which it exerts.

---

* 'The Lancet,' 1863, pages 381 and 412.

From this point of view it is interesting to examine the various articles of food in common use, as to their capabilities for the production of muscular power. The speaker had therefore made careful estimations of the calorific value of different materials used as food, by the same apparatus and in the same manner as described above for the determination of the actual energy in muscle, urea, uric acid, and hippuric acid.

The results are embodied in the following series of tables, but it must be borne in mind that it is only on the condition that the food is digested and passes into the blood, that the results given in these tables are realized. If, for instance, sawdust or paraffin oil had been experimented upon, numbers would have been obtained for these substances, the one about equal to that assigned to starch, and the other surpassing that of any article in the table; but these numbers would obviously have been utterly fallacious, inasmuch as neither sawdust nor paraffin oil is, to any appreciable extent, digested in the alimentary canal. Whilst the force values experimentally obtained for the different articles in these tables must therefore be understood as the maxima assignable to the substances to which they belong, yet it must not be forgotten that a large majority of these substances appear to be completely digestible under normal circumstances.

Actual Energy developed by One Gram of various Articles of Food when burnt in Oxygen.

Name of Food.	Heat Units.		Metrekilograms of Force.		Per cent. of Water.
	Dry.	Natural Condition.	Dry.	Natural Condition.	
Cheese (Cheshire)	6114	4647	2589	1969	24·0
Potatoes	3752	1013	1589	429	73·0
Apples	3669	660	1554	280	82·0
Oatmeal	...	4004	...	1696	...
Flour	...	3941	...	1669	...
Pea-meal	...	3936	...	1667	...
Ground Rice	...	3813	...	1615	...
Arrowroot	...	3912	...	1657	...
Bread Crumb	3984	2231	1687	945	44·0
Ditto Crust	...	4459	...	1888	...
Beef (lean)	5313	1567	2250	664	70·5
Veal "	4514	1314	1912	556	70·9
Ham "	4343	1980	1839	839	54·4
Mackerel	6064	1789	2568	758	70·5
Whiting	4520	904	1914	383	80·0
White of Egg	4896	671	2074	284	86·3
Hard-boiled Egg	6321	2383	2677	1009	62·3
Yolk of Egg	6460	3423	2737	1449	47·0

Actual Energy developed by One Gram of various Articles of Food—continued.

NAME OF FOOD.	Heat Units.		Metrekilograms of Force.		Per cent. of Water.
	Dry.	Natural Condition.	Dry.	Natural Condition.	
Gelatin	4520	...	1914	...	...
Milk	5093	662	2157	280	87·0
Carrots	3767	527	1595	223	86·0
Cabbage	3776	434	1599	184	88·5
Cocoa Nibs	...	6873	...	2911	...
Beef Fat	9069	...	3841	...	...
Butter	...	7264	...	3077	...
Cod-liver Oil	...	9107	...	3857	...
Lump Sugar	...	3348	...	1418	...
Commercial Grape Sugar	...	3277	...	1388	...
Bass'sAle(alcohol reckoned)	3776	775	1599	328	88·4
Guinness's Stout „	6348	1076	2688	445	88.4

Actual Energy developed by One Gram of various Articles of Food when oxidized in the Body.

NAME OF FOOD.	Metrekilograms of Force.	
	Dry.	Natural Condition.
Cheshire Cheese	2429	1846
Potatoes	1563	422
Apples	1516	273
Oatmeal	...	1665
Flour	...	1627
Pea-meal	...	1598
Ground Rice	...	1591
Arrowroot	...	1657
Bread Crumb	1625	910
Lean of Beef	2047	604
Ditto Veal	1704	496
Ditto Ham, boiled	1559	711
Mackerel	2315	683
Whiting	1675	335
White of Egg	1781	244
Hard-boiled Egg	2562	966
Yolk of Egg	2641	1400
Gelatin	1550	...
Milk	2046	266
Carrots	1574	220
Cabbage	1543	178
Cocoa Nibs	...	2902
Butter	...	3077
Beef Fat	3841	...
Cod-liver Oil	3857	...
Lump Sugar	...	1418
Commercial Grape Sugar	...	1388
Bass's Ale, bottled	1559	328
Guinness's Stout	2688	455

Weight and Cost of various articles of Food required to be oxidized in the Body in order to raise 140 *lbs. to the height of* 10,000 *ft.*

External work = ⅕th actual energy.

NAME OF FOOD.	Weight in lbs. required.	Price per lb.		Cost.	
		s.	*d.*	*s.*	*d.*
Cheshire Cheese	1·156	0	10	0	11½
Potatoes	5·068	0	1	0	5¼
Apples	7·815	0	1½	0	11¾
Oatmeal	1·281	0	2¾	0	3½
Flour	1·311	0	2¾	0	3¼
Pea-meal	1·335	0	3¼	0	4½
Ground Rice	1·341	0	4	0	5½
Arrowroot	1·287	1	0	1	3½
Bread	2·345	0	2	0	4¾
Lean Beef	3·532	1	0	3	6½
„ Veal	4·300	1	0	4	3½
„ Ham boiled	3·001	1	6	4	6
Mackerel	3·124	0	8	2	1
Whiting	6·369	1	4	9	4
White of Egg	8·745	0	6	4	4½
Hard-boiled Egg	2·209	0	6½	1	2½
Isinglass	1·377	16	0	22	0½
Milk	8·021	5*d.* per quart.		1	3½
Carrots	9·685	0	1½	1	2½
Cabbage	12·020	0	1	1	0¼
Cocoa-nibs	0·735	1	6	1	1¼
Butter	0·693	1	6	1	0½
Beef Fat	0·555	0	10	0	5½
Cod-liver Oil	0·553	3	6	1	11¼
Lump Sugar	1·505	0	6	1	3
Commercial Grape Sugar	1·537	0	3½	0	5½
Bass's Pale Ale (bottled)	9 bottles.	0	10	7	6
Guinness's Stout	6¾ „	0	10	5	7½

Weight of various articles of Food required to sustain Respiration and Circulation in the Body of an average Man during 24 *hours.*

NAME OF FOOD.	Weight in oz.	NAME OF FOOD.	Weight in oz.
Cheshire Cheese	3·0	Whiting	16·8
Potatoes	13·4	White of Egg	23·1
Apples	20·7	Hard-boiled Egg	5·8
Oatmeal	3·4	Gelatine	3·6
Flour	3·5	Milk	21·2
Peameal	3·5	Carrots	25·6
Ground Rice	3·6	Cabbage	31·8
Arrowroot	3·4	Cocoa-nibs	1·9
Bread	6·4	Butter	1·8
Lean Beef	9·3	Cod-liver Oil	1·5
„ Veal	11·4	Lump Sugar	3·9
„ Ham, boiled	7·9	Commercial Grape Sugar	4·0
Mackerel	8·3		

These results are in many instances fully borne out by experience. The food of the agricultural labourers in Lancashire contains a large proportion of fat. Besides the very fat bacon which constitutes their animal food proper, they consume large quantities of so-called apple dumplings, the chief portion of which consists of paste in which dripping and suet are large ingredients, in fact these dumplings frequently contain no fruit at all. Egg and bacon pies and potato pies are also very common *pièces de résistance* during harvest-time, and whenever very hard work is required from the men. The speaker well remembers being profoundly impressed with the dinners of the navigators employed in the construction of the Lancaster and Preston Railway: they consisted of thick slices of bread surmounted with massive blocks of bacon, in which mere streaks of lean were visible. Dr. Piccard states that the Chamois hunters of Western Switzerland are accustomed, when starting on long and fatiguing expeditions, to take with them, as provisions, nothing but bacon-fat and sugar, because, as they say, these substances are more nourishing than meat. They doubtless find that in fat and sugar they can most conveniently carry with them a store of force-producing matter. The above tables affirm the same thing. They show that ·55 lb. of fat will perform the work of 1·15 lb. cheese, 5 lbs. potatoes, 1·3 lb. of flour or peameal or of 3¼ lbs. of lean beef. Donders, in his admirable pamphlet 'On the Constituents of Food and their Relation to Muscular Work and Animal Heat,' mentions the observations of Dr. M. C. Verloren on the food of insects. The latter remarks, "Many insects use during a period in which very little muscular work is performed food containing chiefly albuminous matter; on the contrary, at a time when the muscular work is very considerable, they live exclusively, or almost exclusively, on food free from nitrogen." He also mentions bees and butterflies as instances of insects performing enormous muscular work, and subsisting upon a diet containing but the merest traces of nitrogen.

We thus arrive at the following conclusions:—

1. The muscle is a machine for the conversion of potential energy into mechanical force.

2. The mechanical force of the muscles is derived chiefly, if not entirely, from the oxidation of matters contained in the blood, and not from the oxidation of the muscles themselves.

3. In man the chief materials used for the production of muscular power are non-nitrogenous; but nitrogenous matters can also be employed for the same purpose, and hence the greatly increased evolution of nitrogen under the influence of a flesh diet, even with no greater muscular exertion.

4. Like every other part of the body, the muscles are constantly being renewed; but this renewal is not perceptibly more rapid during great muscular activity than during comparative quiescence.

5. After the supply of sufficient albuminized matters in the food of man to provide for the necessary renewal of the tissues, the best

materials for the production, both of internal and external work, are non-nitrogenous matters, such as oil, fat, sugar, starch, gum, &c.

6. The non-nitrogenous matters of food, which find their way into the blood, yield up all their potential energy as actual energy; the nitrogenous matters, on the other hand, leave the body with a portion (one-seventh) of their potential energy unexpended.

7. The transformation of potential energy into muscular power is necessarily accompanied by the production of heat within the body, even when the muscular power is exerted externally. This is, doubtless, the chief and, probably, the only source of animal heat.

[E. F.]

WEEKLY EVENING MEETING,

Friday, June 15, 1866.

SIR HENRY HOLLAND, Bart. M.D. D.C.L. F.R.S. President,
in the Chair.

JOHN TYNDALL, Esq. LL.D. F.R.S.
PROFESSOR OF NATURAL PHILOSOPHY, R.I.

Experiments on the Vibrations of Strings.

1. I lay hold of one end of this India-rubber rope, the other end of which is fixed to the ceiling, and by a jerk raise a protuberance upon it. The protuberance runs along the rope to its fixed end, is there reflected, and reversing itself, returns to my hand. In this case, where the points of the rope rise in succession to form the protuberance, we have an example of a *progressive* wave or undulation.

2. After the first wave I now send a second, so that it shall meet the reflected wave on its return. The foremost ends of both waves now meet in the centre of the rope; they there neutralize each other, and the two halves continue to swing with an apparently motionless point called a *node* between them.

3. I now stop the rope, send a wave forward, and then another wave so quickly after it that this second wave shall meet the first at one-third of the length of the rope from its fixed end. At that point a node is produced. But I have already sent a third wave after the second. The second wave being reflected at the node, meets this third one and a second node is formed. The whole rope is now divided into three vibrating parts, separated from each other by two nodes.

4. By properly timing the impulses imparted to the rope I can divide it into four, five, six, ten, and even twenty vibrating parts,

separated from each other by the appropriate number of nodes, With a certain rapidity of vibration on the part of my hand I cause the rope to swing to and fro as a whole. Twice that rapidity divides it into two equal vibrating parts; three times that rapidity into three vibrating parts, and so on. The number of vibrating parts, or *ventral segments,* as they are called, is in fact directly proportional to the rapidity of my hand's vibration.

5. In these cases, where every point of every ventral segment moves to and fro at the same time, we have examples of *stationary* undulations.

6. My hand, which produces this vibration, does not move through more than half-an-inch of space, while the ventral segments oscillate through a space of four-and-twenty. This wide vibration is in fact produced and maintained by the addition together of small impulses properly timed. The nodes, moreover, though apparently motionless, are not strictly so; for if they were, the vibration of the segments would soon come to an end. In fact, it is by the motion transmitted through the nodes that the vibrations of the rope are sustained.

7. I might attach the free end of this rope to any suitable vibrating body instead of taking it in my hand. If the rate of vibration of the body were that of any aliquot part of the rope, it would divide itself accordingly.

8. The effect may also be produced by causing the vibrations of an aliquot part of our rope to excite vibrations in the remaining portion. Stretched vertically from top to bottom of this wooden frame is an India-rubber tube. I encircle the middle of the tube with the finger and thumb of my left hand, and pull the lower half aside with my right. The lower half vibrates, but the upper half vibrates also. In fact, the small amount of play permitted by my hand has enabled the pulse to transmit itself, to be reflected, and to accumulate its motion to this extent. I withdraw my left hand: the tube continues to vibrate in two equal parts, divided from each other by a node.

9. I encircle the tube at one-third of its length from the lower end, and pull aside the shorter segment; it vibrates more quickly than the half tube, and the vibration immediately causes the upper and longer portion to divide into two equal parts. I now withdraw my hand, and the tube continues to vibrate in three equal segments, which are separated from each other by two nodes.

10. In like manner I encircle the tube at one-quarter of its length from its lower end, and pull the lower and shorter segment aside; it vibrates, and forthwith the longer segment above divides into three vibrating parts. I now withdraw my hand, and the tube continues to oscillate in four equal segments, separated from each other by three nodes.

11. Again, from side to side of the room is stretched this stout iron wire twenty-four feet long. I seize the wire at a point which divides

into two parts, one three times as long as the other, and pulling ie shorter segment aside permit it to vibrate ; the remaining portion f the wire divides itself into three ventral segments. I have placed lvered beads at the nodes and at the centres of the vibrating segments ; ou see the light shining from those beads, and you notice that while ie nodal beads remain stationary, the others describe luminous lines.

12. If I place sheets of paper across the wire at the nodes and at ie ventral segments, on causing it to vibrate thus, the sheets placed cross the ventral segments are tossed off, while those at the nodes emain undisturbed.

13. From these effects which you can actually see, I might ass on to vibrating strings, and show you that they divide themselves imilarly. I might also show you that it is hardly possible for a nusical string to vibrate as a whole without having these smaller ibrations riding like parasites upon the large one. The addition f these smaller vibrations gives *quality* or *timbre*, or, as the Germans all it, *Klangfarbe* to the note. They constitute the harmonics of the tring.

14. In this vice is fixed upright a rod of iron four feet long. I ull it aside and it vibrates as a whole; its vibrations are rendered nore distinct by casting its shadow upon a white screen. I now trike the rod sharply at a point about one-third of its length from its ixed end. The pulse runs along the rod; returns from its free nd, and is met by the succeeding pulses; and now the rod is divided nto two vibrating parts,—a whole segment and a half segment separated rom each other by this dark motionless node. By promptly striking he rod lower down, I cause it to divide into two complete vibrating egments, forming those shadowy spindles upon the screen, and half segment at the top which spreads out like a fan. The nodes are narked by the two dark points where the shadow is complete.

15. This production of stationary undulations on a large scale hrough the combination of direct and reflected waves, for the illustraion of which we are mainly indebted to the brothers Weber, forms a fit ntroduction to the experiments of M. Melde, of Marburg, who has btained a series of very beautiful effects by associating with vibrating odies suitably stretched strings.

16. In M. Melde's first experiment he stretched a string across a bell, r bell-jar, from edge to edge; when the bell was caused to vibrate, he string vibrated also. By varying the tension of the string it was aused to vibrate as a whole, or to divide itself into two, three, four, ive or more vibrating parts, separated from each other by the appropriate number of nodes.

17. He then attached his strings to tuning-forks, and obtained the ame effect in a more marked and beautiful manner. To this tuningfork I have attached a silk string which passes round a distant peg, by urning which the string is stretched. The length of the string is

eight feet. The tension at the present moment is such, that when the fork is caused to vibrate, the string swings as whole; its periods of vibration being synchronous with the impulses imparted to it by the fork. We have here a beautiful gauzy spindle produced by the silk, fully six inches wide at its point of greatest amplitude.

18. The motion of the end of the string in contact with the fork is hardly sensible, and still through this apparently motionless part of the string the whole of its motion is transmitted.

19. I relax the string by turning the peg, and now it suddenly divides itself into two ventral segments, separated from each other by a node. When the synchronism between the fork and string is perfect, the vibrations of the string are steady and long-continued; but a slight departure from synchronism introduces unsteadiness, and the vibrations, though they may show themselves for a time, quickly disappear.

20. I relax the string still further; it now divides itself into three vibrating parts; relaxing still further, it divides into four vibrating parts; and thus I might continue to subdivide the string into ten or even twenty equal parts, separated from each other by a number of nodes one less than the number of ventral segments.

21. In the arrangement now before you, the fork vibrates in the direction of the length of the string; its tendency, therefore, is to throw the string into longitudinal vibration. But, in fact, every forward stroke of the fork raises a protuberance upon the string, which runs to its fixed end and is there reflected, so that when the longitudinal impulses are properly timed, they produce a transverse vibration. I take a heavy string in my hand, stretch it, and move my hand to and fro in the direction of the string. It vibrates as a whole, and I notice that it is always when the string is at the two limits of its excursion that my hand moves forward. If the string vibrate in a vertical plane, my hand, in order to time the impulses properly, must move forward at the moment the string reaches the upper and also at the moment it reaches the lower limit of its excursion. A little reflection will make it plain, that, in order to accomplish this, my hand must execute a complete vibration while the string executes a semi-vibration;* in other words, the vibrations of my hand must be exactly twice as rapid as those of the string.

22. Precisely the same must be true of a tuning-fork to which a proper string is attached. When the fork vibrates in the direction of the string, the number of complete vibrations which it executes in a certain time will be twice the number executed by the string.

---

* A complete vibration, it will be borne in mind, consists of one complete excursion to *and fro*. A semi-vibration, on the contrary, consists of an excursion from one limit of the vibration to the other.

23. If in this case the fork and string vibrate with sufficient rapidity to produce musical notes, the note of the fork will be an octave above that of the string. That it is so has been proved by M. Melde's direct observations.

24. Taking hold of the end of this heavy string, I cause my hand to move to and fro, not in the direction of the string, but at right angles to that direction. The string now swings as a whole in a vertical plane. Here every upward movement of my hand coincides with an upward movement of the string, every downward movement of my hand with a downward movement of the string. In fact, the vibrations of hand and string in this case synchronise perfectly; and if the hand could emit a musical note, the string would emit a note of the same pitch. The same holds good when a vibrating fork is substituted for the vibrating hand. While, therefore, when the vibrations are longitudinal, a complete vibration of the fork synchronises with a semi-vibration of the string: when the vibrations are transversal, a complete vibration of the fork corresponds to a complete vibration of the string.

25. Hence, if the string vibrate as a whole when the vibrations are longitudinal, it will divide itself into two ventral segments when the vibrations are transversal; or, more generally expressed, preserving the tension constant, whatever be the number of ventral segments produced by the fork when its vibrations are longitudinal, twice that number are produced when the vibrations are transverse. Here, for example, is a string eight feet long, vibrating longitudinally; the fork divides the string into four equal vibrating parts. I place the fork so that it shall vibrate at right angles to the string. The number of ventral segments is now eight, or double the former number. This result was amply illustrated by the experiments of M. Melde.

26. Attaching two strings of the same length to the two prongs of the same fork, stretching one string in the direction of the prongs, and the other at right angles to that direction, and subjecting the strings to the same tension, when the fork is caused to vibrate, the one string divides itself into double the number of vibrating segments exhibited by the other.

27. When white silk strings vibrate thus, the beauty of the ventral segments is extreme. The nodes appear white and fixed, while the vibrating parts form delicate gauzy spindles in the air; every protuberance of the twisted string writes its motion in a more or less luminous line on the surface of the aërial gauze.

28. Certain twisted strings do not adhere to the same plane. They vibrate simultaneously in two rectangular directions, and every one of their points describes a closed curve. When the two vibrations are of the same amplitude, and have the proper difference of phase, the ventral segments describe surfaces of revolution.

29. The path described by the various points of the string may be studied after the manner of Dr. Young, by throwing light upon them and watching the lines described by the illuminated points. By twisting a flat and burnished silver wire we form a spiral surface, from which at regular intervals the light flashes, when the whole wire is illuminated. Attaching the wire to a tuning-fork and causing it to vibrate, its luminous spots describe luminous lines. If the wire vibrate as a whole without any sensible admixture of its harmonic divisions, these spots describe straight lines which are drawn brilliantly across the ventral gauze; but when by slackening or tightening the wire, other vibrations are caused to mingle with the fundamental one, the combination of vibrations expresses itself in luminous scrolls of extraordinary beauty.

30. But to see this beauty you must be close to it. The vibrating segments of our silk strings were, I fear, also too faint to be seen at a distance. For the silk string I substitute a fine platinum wire, which now stretches from this tuning-fork over a bridge of copper, and then round a peg. I send an electric current through the wire, which now glows brightly. I sound the fork: the wire vibrates as a whole: its two ends are brilliant, but its middle is chilled by its rapid passage through the air. Thus you have a shading off of incandescence from the ends to the centre of the wire. I relax the tension; the wire now divides itself into two vibrating parts; I relax still further and obtain three; still further, and now you have the wire divided into four, ventral segments separated from each other by these three brilliant nodes. Right and left from every node, the incandescence shades away until it disappears. You notice also that when the wire settles into steady vibration the nodes shine out more brilliantly than the wire shone before the vibration commenced. This is due to the cooling of the vibrating segments. When they are chilled by their swift passage through the air, their conductivity is improved. More electricity passes through the vibrating than through the unvibrating wire, and hence the augmented glow of the nodes.

31. Certain twisted chords, as I have said, when attached to tuning-forks execute circular instead of plane vibrations. Circular vibrations may always be obtained by attaching one end of a string to a rotating point, and timing the velocity of rotation to suit the periods of vibration possible to the string.

32. Thus, suspended from the ceiling is this white cotton rope, the lower end of which is attached to a hook belonging to this whirling table. When this handle is turned the hook rotates, describing a circle less than an inch in diameter. By properly regulating the velocity of rotation I cause the rope to divide into a series of spindles, which appear like gray gauze when projected against a dark background. I can cause the number of these spindles to vary from one to twenty by varying the velocity of rotation.

33. In this experiment the rope is vertical and the rotating wheel horizontal, but I have here an arrangement in which the wheel is vertical and the vibrating chord horizontal. Instead of a rope I now employ a burnished silver chain. Turning this wheel slowly I cause the chain to swing as a whole, and describe a spindle twelve feet long and nearly two feet in diameter at its widest part. Augmenting the speed of rotation I divide the chain into two spindles, each six feet long and more than a foot in diameter; a still higher velocity gives us three spindles, a still higher four, and so on. The gas-light here flashes at intervals from the burnished links of the chain, and each of those brilliant points describes a curve of light.

34. As soon as synchronism is established between the wheel and the chain, the amount of work performed by the arm which turns the wheel is very sensibly augmented. Indeed it may be augmented until the strain thrown upon the chain by the accumulation of small impulses is sufficient to break it.

35. I substitute for the chain this lighter cotton-rope, round which a silver band has been coiled as a spiral; and from an electric lamp placed at the end of the rope I send a beam of light along its entire length. I now turn the wheel and divide the rope successively into two, three, four, or five ventral segments. The spindles show a graduated brilliancy, which is intensified until it becomes almost dazzling at the nodes. The vibrating chord is, indeed, better seen when the light that falls upon it has been caused to pass through coloured glass. We thus obtain at pleasure green, blue, and red spindles, with nodes like fire shading off into the more subdued light of the ventral segments.

36. Substituting for the cotton rope a string of silvered beads, twelve feet long, I send the beam from the electric lamp along the string. On every bead rests a spot of light of sunlike brilliancy. When the wheel is turned, each spot describes a circle, and every ventral segment, of which we have now four, seems formed of a series of such dazzling parallel rings, which diminish in size right and left from the points of maximum amplitude till the diameters vanish at the nodes.

37. So much for physical beauty; we have now to revert to beauty of another kind. The experiments with tuning-forks above described, may be extended to the establishment of all the laws of vibrating strings. I have here four forks, *a*, *b*, *c*, *d*, whose vibrations are in the proportion of the numbers 1, 2, 4, 8. Attaching a string eight feet long to the largest fork, I stretch it by a weight which causes it to vibrate as a whole. Keeping the stretching weight or tension the same, I attach pieces of the string to the other forks, and determine in each case the length which swings as a whole. These lengths are in the ratio of 8, 4, 2, 1.

38. *Hence the rapidity of vibration is inversely proportional to the length of the string.*

39. Here the string, eight feet long, vibrates as a whole when attached to the fork *a*. I now transfer it to *b*, still keeping it stretched by the same weight. It vibrates when *b* vibrates; but how? By dividing into two equal ventral segments. In this way alone can it accommodate itself to the vibrating period of *b*. Attached to *c*, the same string separates into four, while when attached to *d* it divides into eight ventral segments. This may be deduced immediately from the law enunciated in 38, and its experimental realization reacts as a proof of that law.

40. This result admits of extension. I have here two tuning-forks separated from each other by the musical interval called a fifth. Attaching a string to one of the forks I stretch until it divides into two ventral segments; attached to the other fork, and stretched with the same weight, the string divides instantly into three segments when the fork is set in vibration. Now to form the interval of a fifth the vibrations of the one fork must be to those of the other in the ratio of 2 : 3. The division of the string, therefore, declares the interval. Here also are two forks separated by an interval of a fourth. With a certain tension one of the forks divides our string into three ventral segments; with the same tension the other fork divides it into four, which two numbers express the ratio of the vibrations. In the same way the division of the string in relation to all other musical intervals may be illustrated.

41. Again. Here are two tuning-forks, *a* and *b*, one of which (*a*) vibrates twice as rapidly as the other. I attach this string of silk to *a*, and stretch the string until it synchronises with the fork and vibrates as a whole. I now form a second string of silk of the same length, by laying four strands of the first side by side. I attach this compound thread to *b*, and keeping the tension the same as in the last experiment, set *b* in vibration. The compound thread synchronises with *b*, and swings as a whole. Now, by quadrupling the original thread, I obtained a string of twice the diameter of the original one: for the transverse section of any string is as the square of its diameter. Hence, as the fork *b* vibrates with half the rapidity of *a*, by doubling the diameter of the string, I halved its rapidity of vibration. In the same simple way it might be proved that by trebling the diameter of the string we reduce the number of its vibrations to one third. In general terms:—

42. *The rapidity of vibration is inversely proportional to the diameter of the string.*

43. A beautiful confirmation of this result is thus obtained:—Attached to this tuning-fork is a silk string six feet long. Two feet of this string are composed of four strands of the single thread, placed side by side, the remaining four feet are a single thread. I apply a tension, which causes the string to divide into two ventral segments.

But how does it divide? Not at its centre, as is the case when the string is of uniform thickness throughout, but at the point where the thick string terminates. This thick segment, two feet long, is now vibrating at the same rate as the thin segment four feet long, a result which must manifestly follow from the combination of the two laws which we have already established. I need hardly say that if the lengths were in any other ratio than 1 : 2, the node would not be formed at the point of union of the two strings.

44. We have now to establish the third law of vibrating chords. Here are two strings of the same length and thickness. One of them is attached to the fork *b*, the other to the fork *a*, which vibrates with twice the rapidity of *b*. Stretched by a weight of 20 grains placed on this balanced scale-pan, the string attached to *b* vibrates as a whole. Substituting the fork *a* for *b*, I find that a weight of 80 grains causes the string to vibrate as a whole. Hence to double the rapidity of vibration we must quadruple the stretching weight. In the same way it might be proved that to treble the rapidity of vibration we should have to make the stretching weight nine-fold. In general terms :—

45. *The rapidity of vibration is proportional to the square root of the tension.*

46. In the foregoing experiment both the tension and the rate of vibration were caused to vary. We will now cause the tension alone to vary, and observe the effect upon the entire string. I carry this silk chord from this tuning-fork to the scale-pan, and stretch it by a weight of 80 grains. The string vibrates as a whole. By diminishing the weight I relax the string, which finally divides sharply into two ventral segments. What is now the stretching weight? 20 grains. With a stretching weight of almost exactly 9 grains it divides into three segments, while with a stretching weight of 5 grains it divides into four segments. Thus then a tension of one-fourth doubles, a tension of one-ninth trebles, a tension of one-sixteenth quadruples the number of ventral segments. In general terms, the number of segments is inversely proportional to the square root of the tension. This result may be deduced by reasoning from the laws enunciated in 38 and 45, and its realization in fact confirms their correctness.*

47. Finally, I have here three wires of the same length and thickness, but of very different densities; one of them is of the light metal aluminium, another of silver, and another of the heavy metal platinum. I attach the wires in succession to this tuning-fork, and determine the weights necessary to cause them to vibrate as a whole, or to form the same number of ventral segments. The stretching weights here necessary I find to be directly proportional to the specific

---

* This experiment, in whole or in part, has been already performed by Prof. Foster, of University College.

gravities of the wires. From this result, combined with that enunciated in 45, it follows that—

48. *The rapidity of vibration of different chords of the same length and thickness is inversely proportional to the square root of their densities.*

49. It is, perhaps, worth remarking that, by means of a tuning-fork, the specific gravities of all metals capable of being drawn into wires of sufficient fineness and tenacity may be determined.

The foregoing laws have been combined in various ways; and the deductions drawn from them, when subjected to the test of direct experiment, have, in every instance, been verified.

[J. T.]

GENERAL MONTHLY MEETING,

Monday, July 2, 1866.

Sir Henry Holland, Bart. M.D. D.C.L. F.R.S. President, in the Chair.

His Royal Highness The Duke of Edinburgh, K.G.

was *elected* an Honorary Member of the Royal Institution.

Richard Cockerton, Esq.

was *elected* a Member of the Royal Institution.

The Presents received since the last Meeting were laid on the table, and the thanks of the Members returned for the same, viz.:—

FROM

Her Majesty's Government (through Sir R. I. Murchison).—Memoirs of the Geological Survey of Great Britain. Vol. III. 8vo. 1866.
Governor-General of India—Geological Survey of India.
  Memoirs: Vol. IV. Part 3. Vol. V. Part 1. 8vo. 1865.
  Catalogue of Echinodermata, &c. 8vo. 1865.
  Palæontologica Indica, III. 6-9; IV. 1. 4to. 1864-5.
  Annual Report. 8vo. 1864-5.
Trustees of the British Museum—Cuniform Inscriptions of Asia. Vol. II. fol. 1866.
Committee on Meteorological Department of the Board of Trade—Report. fol. 1866.
Commissioners in Lunacy—Twentieth Report. 8vo. 1866.
Astronomical Society, Royal—Monthly Notices, 1865-6. No. 7. 8vo.
Bavarian Academy of Science, Royal—Sitzungsberichte, 1866. Band I. 1, 2. 8vo.
Chemical Society—Journal for June, 1866. 8vo.
Corporation of London—Catalogue of the Library. Sixth Supplement. 8vo. 1866.

Editors—Artizan for June, 1866. 4to.

Athenæum for June, 1866. 4to.

British Journal of Photography for June, 1866. 4to.

Chemical News for June, 1866. 4to.

Engineer for June, 1866. fol.

Horological Journal for June, 1866. 8vo.

Journal of Gas-Lighting for June, 1866. 4to.

Mechanics' Magazine for June, 1866. 8vo.

Pharmaceutical Journal for June, 1866.

Practical Mechanics' Journal for June, 1866. 4to.

Faraday, Professor, D.C.L. F.R.S.—Kais. Akademie der Wissenschaften: Wien.

Math Nat. Classe:—Denkschriften, Band 23, 24. 4to. 1864–5.

Sitzungsberichte. Abth. I. 1865. Nos. 3–7. 8vo. Abth. II. 1865. Nos. 3–8. and Register. 8vo.

Almanach, 1864 and 1865.

H. A. and R. de Schlagintweit—Results of a Scientific Mission to India and High Asia. Vols. I. II. III. IV. and Atlas 1, 2, 3, 4. 4to. 1861–6.

E. Schlagintweit—Buddhism in Tibet. 8vo, with Atlas. 1863.

Atlas der Hautkrankheiten, Lief. 4, 5. 1864–5.

Franklin Institute—Journal, Nos. 484, 485. 8vo. 1866.

Gilbert, James, Esq. (*Executors*)—Works of James William Gilbert, F.R.S.—6 vols. 8vo. 1865.

Linnean Society—Journal and Proceedings, Zoology, No. 37. 8vo. 1866.

Meteorological Society—Proceedings, No. 25. 8vo. 1866.

Murchison, Sir Roderick I. Bart. K.C.B. (*the Author*)—Address to Royal Geographical Society, 28th May, 1866. 8vo.

Oakes, Lieut.-Col. W. H. (*the Author*)—Machine-Table for determining Primes and the least Factors of Composite Numbers up to 100,000. (In sheets.)

Photographic Society—Journal, No. 170. 8vo. 1866.

Royal Society of London—Proceedings, No. 84. 8vo. 1866.

San-German de Leandro (*the Author*)—Ensayo para utilizar como Fuerza motriz el Calor Solar y la Presion admosferica. (K 94) 8vo. 1866.

United Service Institution, Royal—Journal, No. 38. 8vo. 1866.

Catalogue of the Library. 8vo. 1865.

Vereins zur Beförderung des Gewerbfleisses in Preussen—Verhandlungen, Jan. und Feb. 1866. 4to.

INDEX TO VOLUMES I. II. III. & IV.

Abel, F. A., on the Application of Science to Military Purposes, II. 283; III. 243.
—— on Explosions and their Military Applications, III. 438.
—— on the Chemical History and Application of Gun-cotton, IV. 245.
—— on Proposed Substitutes for Gunpowder, IV. 616.
Absorption of Heat, IV. 487, 489.
Acetylene, IV. 18.
Acids and Salts, III. 234.
Acoustic Experiments, II. 441.
Actonian Prize (1851), awarded to Mr. Wharton Jones, I. 54; (1858), Subject announced, II. 1; No Award, 526; (1865), awarded to G. Warington, IV. 399.
Aeby, on Nervous Contraction, IV. 589.
Aggregation, Material, I. 254; its relation to Radiation, IV. 487.
Agrarian Laws of Lycurgus, IV. 268.
Air, Estimation of Organic Matter in, III. 89; see *Atmosphere.*
Airy, G. B., on the Total Eclipse of 1851, I. 62.
—— on the Eclipse of Thales, &c., I. 243.
—— on Pendulum Experiments at Harton, II. 17.
Albert, Prince Consort, Present from, III. 163; Address respecting his Decease, IV. 404, 418.
Albert Nyanza Lake discovered, IV. 503.
Alison, S. S., on certain Auditory Phenomena, III. 63.
Allen, Ralph, improves Postal System, III. 459.
Allotropic Changes, I. 133, 201.
Alps, Geology of, I. 31; of Savoy, IV. 142.
Aluminium, Specimens exhibited, II. 79, 85; Rev. J. Barlow on, 215.
Aluminium-Ethide and Methide, IV. 343.
America, North, Physical Geography, II. 167, 522.
Ammonia, a chemical type, II. 274.
Analytically formed Substances by the Body, IV. 568.
Anderson, Charles, Decease of, IV. 516.
Andes, Minerals of, III. 190.
Anhydrous Organic Acids, I. 239.
Aniline, History of, III., 475; IV. 437.
Anima Mundi, IV. 512.
Animal Individuality, I. 184; Forms, 444.
—— and Vegetable Kingdoms, Limits, I. 415; Structure, 298.
—— Life, Persistent Types of, III. 151; in the Deep Sea, 299.
—— Quinoidine, IV. 567.
Animals, Earliest Stages of their Development, III. 315.
Annual Meetings (1851) I. 61; (1852) 190; (1853) 309; (1854) 433; (1855) II. 96; (1856) 254; (1857) 421; (1858) 524; (1859) III. 132; (1860) 252; (1861) 361; (1862) 484; (1863) IV. 97; (1864) 282; (1865) 433; (1866), 615.
Ansted, D. T., on Mud Volcanoes and Petroleum, IV. 628.
Antiquity of Man, IV. 38.
Antozone, III. 70.
Apes, Anthropoid, II. 26; III. 16.
Aphis, Development of, I. 11, 14; II. 535.
Appert's Mode of Preserving Food, II. 77.
Aquarium, II. 403.
Aqueous Vapour, condensed and frozen, IV. 5; see *Vapours.*
Arabia, Eastern and Central, IV. 348.
Arabic Philosophy, IV. 506.
Architecture, its relations to Science, IV. 124; Constructive Principles of the Styles, 268.
Armstrong's Time-fuzes, III. 448.
—— Gun, its Construction, III. 246; its Powers, 500.
Art and Science, points of contact between, IV. 9.
—— illustrated by Coins, IV. 306.
—— Education, IV. 380.
Artificial Illumination, IV. 16.
Ashby, Rev. J. E., on Catalytic Action, II. 66.
Assyrian and Babylonian Excavations, II. 143.
Astronomy and Photography, II. 462.
Atlantic Telegraph, II. 401.
Atlantis, on the Theory of an, III. 431.

[illegible] Electricity, iv. 277.
[illegible]sphere, Radiation through, iv. 4;
— Opalescence, 651.
[illegible]micities of the Elements, iv. 275.
[illegible]oms, their combining power, iv. 401.
[illegible]ulatory Phenomena, [illegible]
[illegible]
[illegible] Coal in South
[illegible]
[illegible]
[illegible]

[illegible] and Nineveh, on Discoveries
[illegible] iii. 336; iv. 585.
[illegible] Temple of Thales, ii. 244;
[illegible] Sea, 4.
[illegible] Printing Telegraph, i. 358.
[illegible] on the Sources of the
[illegible]
[illegible] Property purchased, iv. 251.
[illegible] Ascent, i. 437.
— [illegible] Experiments, iv. [illegible]
[illegible] Manufacture of, ii. [illegible]
[illegible] on Silica, i. 422.
[illegible] Application of Chemistry to
[illegible] Preservation of Food, ii. 72.
[illegible] Aluminium, ii. 215.
[illegible] Vegetable Fibre and Parchment
[illegible]
— [illegible] Mineral Candles, &c., manu[illegible] Belmont and Sherwood
[illegible]
— [illegible] Portrait painted and presented [illegible] W. Pickersgill, iii. 1.
— [illegible] the Secretaryship, iii. 291; [illegible] General Meeting [illegible] 313; Letter from, 329.
[illegible] Cartesian, i. 426.
[illegible] W. F., engaged as Assistant in the Laboratory, iv. 156.
[illegible], T., Plea for Cotton, iii. 514.
[illegible]querel, E., Electrical Researches of, [illegible] 338, 360.
[illegible] Phosphorescence, iii. 160.
[illegible] Great, of Westminster, ii. 368.
[illegible] Jacob, presents Gould's Works on [illegible]irds, iii. 154.
[illegible] Messrs., present Seven Pounds of [illegible], iv. 153.
[illegible] List of, ii. 384.
[illegible], ii. 507.
[illegible] Experiment on the Impact of [illegible] of Light, iv. 560.
[illegible] discovered by Faraday, iii. 482; [illegible] to Mauve, 477.
[illegible] Acetylene [illegible]
[illegible] Transmission [illegible]

Bigsby, J. J., on Lake Sc
Blackheath Pebble-bed [illegible]
Blackie, J. S., on the Sta tution and the Agra Lycurgus, iv. 293.
Blakeley's Gun, iii. 24
Blind, Education of the [illegible] for their Management [illegible]
Boiling Water, Phenomena
Bonelli's Electric Silk-Loo
Botfield, B., Legacy from
Boutigny, M., Etudes sur l'etat spheroidal, i. 17
Boussingault's Mode of pr gen, i. 337.
Bowditch's Method of pu Gas, iv. 17.
Bradbury, H., on Nature-Pr
— on Bank Notes, ii.
— Present from, ii. 14
— on Printing [illegible]
Brain of Man and Apes [illegible]
Brande, W. T., on Peat, [illegible]
— on Electro-magnetic C
— Address on resigning [illegible] ship, i. 168; Report of [illegible] respecting, 170; elected [illegible] fessor of Chemistry, 171.
— Decease, iv. 550.
[illegible], Dr. F., Nature-[illegible]
[illegible]making, iii. 253.
[illegible], J. W., on Submarine [illegible] 364.
British Seas, Natural His
Brixham Hill Cavern, iii. [illegible]
Brockedon, W., on Caoutc
— on Foreign Wines an on the Grape, i. 303.
Brodie, B. C., on Allotrop i. 201.
— on Hydrogen and its [illegible] i. 325.
— on Melting Points, i. [illegible]
— on Ozone, iii. 71.
Bronze Age, iv. 32.
Brooke, C., on the Comp matic Microscope, i. 402.
Brookfield, W. H., on Oral [illegible] 241.
Broughton, J., engaged as [illegible] Laboratory, iv. 156.
Buckland, Frank, on the [illegible] Fish, iv. 75.
Buckle, H. T., on Influence on the Progress of Knowl
Buddhism in India, iv. 13
[illegible] Kirchhoff's Sp [illegible] 393, 396.

Bunsen's Measurement of the Sun's Chemical Action, iv. 129.
Burdett-Coutts Geological Scholarship, iii. 264.
Bye-law suspended, iv. 156, 177.

CÆSIUM, iii. 325.
Calcium, iii. 83.
Calico-Printing, its Processes and Improvements, iii. 201.
Calvert, F. C., on Chevreul's Laws of Colours, ii. 428.
—— on the Influence of Science on Calico-Printing, iii. 201.
Canada, Geology of, ii 522.
Candles, Manufacture of, i. 21; Mineral, &c. ii. 506.
Cannon, Construction of, iii. 244.
Caoutchouc, Properties and Applications of, i. 42; iii. 250.
Carpenter, W. B., on the Influence of the Suggestion on Muscular Movement, i. 147.
—— on the Rhizopod type of Animal Life, ii. 497.
—— on the Relation of the Vital to the Physical Forces, iii. 206.
Carpmael, W., on the Manufacture of Candles, i. 21.
Catalogue of Library, New, ii. 446.
Catalytic Action, ii. 66.
Cattle of Britain, ii. 259.
Cerebral System of Classification, iii. 174.
Chameleon, Mineral, iii. 89.
Charcoal, a Sanitary Agent, ii. 53.
Chaucer's Life and Works, ii. 248.
Chemical Circulation in the Body, iv. 449.
—— Action of Solar Rays, iii. 210; of Diffused Daylight, iv. 653.
—— Discoveries from the Great Exhibition, i. 131.
—— Affinity, i. 416.
—— Dynamics, i. 90.
—— Forces connected with Polarization of Light, i. 45.
—— Properties of Compounds, i. 451.
Chemistry, Military, ii. 283; Agricultural, 289; of Light, 223; see *Sun*.
Chevreul, M., Laws of Colours, ii. 428.
Chinese Lists of Meteors, iii. 143.
—— Library presented, iii. 212.
Chlorate of Potash as a substitute for Gunpowder, iv. 617.
Chorley, H. F., on English Poetry with reference to Music, iii. 317.
Chromatic Phenomena, ii. 338.
Chronometry of Life, iii. 117.
Chronoscopes, iv. 577.
Clark's Process of Purifying Water, ii. 467.
Clark, Latimer, on Electrical Quantity and Intensity, iii. 337.
Classification of the Elements by the Atomicities, iv. 275.
Cleavage of Rocks, &c. ii. 298.
Coal, Formation of, i. 284; iii. 510.
—— English, ii. 59, 511; American, 181; Power of, 184.
Coal-gas, Manufacture of, &c. i. 320.
Coal-tar Colours, History of, iii. 468; Specimens of, 483.
Cobbold, T., on Natural History Sciences (*no abstract*), iii. 243.
Coles's Shield-vessel, iii. 509.
Colloids, iii. 424.
Colne River Water, ii. 49.
Colour of Bodies in relation to their state of Aggregation, iv. 489.
Colours, Laws of, ii. 428; the Three Primary, iii. 370.
Combustion in Rarefied Air, iii. 331.
Compass Deviations in Iron Ships, iv. 518.
Conolly, Dr. J., on the Condition of the Insane (*no abstract*), i. 303; on the Characters of Insanity, 375.
Conservation of Force, ii. 352; and Organic Nature, iii. 347.
Cookery, Military, &c. ii. 422.
Cottager's Stove, ii. 423.
Cotton, Plea for, iii. 514.
Coulvier-Gravier on Meteors, iii. 145.
Cowper, E., on Lighthouses, i. 24; on Locks, 163 (*no abstract*).
Coxwell, Mr., Balloon Ascents, iv. 71.
Crimean Mud Volcanoes, iv. 628.
Crookes, W., on the Discovery of Thallium, iv. 62.
Crystal Molecule, iii. 95.
Crystallographic Models, iii. 86, 88.
Crystalloids, iii. 424.
Cuneiform Characters, early Use of, i. 84.
—— Discovery, iii. 536; iv. 335.

DANTE, on, ii. 118.
Darwin's Origin of Species considered, iii. 195, 228.
Deep-sea Bed, its Nature, iii. 299.
De Jaager, on Nervous Agent, iv. 590.
De la Rue, Warren, his Photographs of the Moon, exhibited, ii. 462.
—— Chemical Discoveries, &c., ii. 506, 508.
—— Photographic Eclipse Results, iii. 362.

De la Rue, Warren, presents Electric Lamp, &c. III. 418, 540.
—— Photographs of the Sun, IV. 378.
Denison, E. B., on the Great Bell of Westminster, II. 368.
—— on Locks, II. 475.
—— on Modern Gothic Architecture, III. 32.
Development of Animals, III. 315.
Deville, M., Experiments on Aluminium, II. 215; elected Hon. M.R.I. 413.
Devonshire Caverns and Fossil Mammalia, III. 149, 150.
Dialysis, Graham's, III. 422.
Dia-magnetism, II. 159.
Diamonds, Nature of, III. 229.
Dickinson, J., on Supply of Water for London, II. 47.
Dietaries, Table of, I. 316.
Diffusion, Chemical, III. 423.
D'Orsey, A. J., on the Study of the English Language, III. 307.
Dodd, G., Legacy from, IV. 346.
Dollond's Improvement of the Telescope, IV. 642.
Donation Fund for the Promotion of Experimental Researches established, IV. 151; Contributions to, 153, 156, 177, 231, 243, 290, 316, 323, 325, 328, 347, 372, 435, 464, 483, 516, 549, 572, 660.
Donations for Promoting Scientific Research, IV. 108, 109.
Doncaster new Churches, III. 40.
Donders' Experiments on the Human Eye, IV. 572.
Donne, W. B., on Chaucer, II. 248.
Donny, on Boiling Water, IV. 158.
Dreaming, IV. 207.
Dresser, C., on Science and Ornamental Art, II. 350.
Druitt, R., on Houses in relation to Health, III. 133.
Du Bois-Reymond, E., on the Time required for the Transmission of Volition and Sensation through the Nerves, IV. 575.
Du Chaillu, F., Narrative of his Travels in Western Central Africa (*no abstract*), III. 335.
Dupré, Dr., Experiments on Chemical Circulation in the Body, IV. 564.
Durham, A., on Sleeping and Dreaming (*no abstract*), III. 430.

EARTH, its Magnetism, I. 57; Measurement, &c. II. 17, 519; Temperature, &c. III. 139.
Earthquakes in South Italy, II. 528.
Ebelmen's Mode of producing Artificial Rubies, &c. I. 83.
Eclipse of Thales, I. 243; of Agathocles, 248; of 1851, &c. 62.
Eclipse, on Photographs of, by W. De la Rue, III. 362.
Eclipses, Phenomena of, I. 65; Computation of, 243.
Edinburgh, Duke of, elected Honorary Member, IV. 694.
Education in Science, II. 556; in Art, IV. 380.
Electric Currents in Plants, I. 75.
—— Induction, I. 345.
—— Force, I. 217.
—— Telegraph Wire, Experiments on, I. 346; Piece of, exhibited, 442.
—— Telegraph, II. 394, 557.
—— Quantity and Intensity, III. 337.
—— Discharge, Action of Magnetic Force on it, III. 169.
—— Light employed in Lighthouses, III. 221.
—— Silk-loom, III. 271.
Electricity, Transmission of, by Flame and Gases, I. 359; Velocity of, in different kinds of Wire, 352; Heating Effects of, 119.
—— Military Applications of, III. 249.
—— Atmospheric, III. 277.
Electro-biology, I. 147.
Electro-magnetic Clocks, I. 109.
Encke's Calculations on Pons' Comet, IV. 562.
English Language, Study of, III. 307.
—— Poetry with reference to Music, III. 317
Entasis, Tables of, I. 128.
Eozoön, Discovery of, IV. 374.
Ethnology, Methods and Results of, IV. 461.
Ethyl, Production of, I. 326.
Etna, Structure of, III. 129.
Evans, J., on the Forgery of Antiquities, IV. 356.
Exhibition of 1851, Remarks on, I. 151.
—— of 1862, Discourse on, III. 485.
Explosions, Causes of, &c. III. 438.

FAIRBAIRN, W., on Iron and its Resistance to Projectiles, III. 491.
Faraday, M., on the Magnetic Relations of Oxygen and Nitrogen, I. 1.
—— on Atmospheric Magnetism, I. 56.
—— on Electric Currents in Plants, I. 75.
—— on Artificial Production of the Ruby, &c. by M. Ebelmen, I. 83.
—— on Schönbein's Ozone, I. 94.

Faraday, M., on the Lines of Magnetic Force, I. 105, 216, 229.
—— on the Researches of Boussingault and others on Oxygen, I. 337
—— on Electric Induction—Associated cases of current and stated effects, I. 345.
—— on Vibrations and Tones of Heated bodies, I. 356, 358.
—— on Magnetic Hypotheses, I. 457.
—— on Magnetic Philosophy, II. 6, 196.
—— on Gravity, II. 10.
—— on Electric Conduction, II. 123.
—— on Ruhmkorff's Induction Apparatus, II. 139.
—— on Petitjean's Silvering Process, II. 308.
—— on Divided Gold, II. 310; IV. 659.
—— on the Conservation of Force, II. 352.
—— on the Relations of Gold to Light, II. 444.
—— on Static Induction, II. 470, 490.
—— on Wheatstone's Electric Telegraph, &c. and Scientific Education, II. 556.
—— on Schönbein's Ozone and Antozone, III. 70.
—— on Phosphorescence, Fluorescence, &c. III. 159.
—— on Lighthouse Illumination—the Electric Light, III. 220.
—— on Electric Silk-Loom, III. 271.
—— on Platinum, III. 321.
—— on De la Rue's Photographic Eclipse Results, III. 362.
—— on Gas-Furnaces, III. 536.
—— his Letter to the Prince of Wales, IV. 3.
—— a Bust of him presented, IV. 14.
Faulhorn, Physiology of its Ascent, IV. 572.
Fawcett, H., on Wealth and those who produce it (*no abstract*), IV. 434.
Fergusson, J., on the Holy Sepulchre and the Temple at Jerusalem, III. 426; IV. 366.
Fick, Dr., on Source of Muscular Power, IV. 654 *et seq.*
Field, F., on the Minerals of the Andes, III. 190.
—— on Magenta and its Derivative Colours, IV. 437.
Fireballs, IV. 88.
Fish-culture, IV. 75.
Fitz-Roy, R., on Meteorological Telegraphy, III. 444.
Fixed Stars, their Constitution, IV. 441.
Fizeau, M., Photographic Engraving, II. 346.
Flint Implements of Abbeville, &c. IV. 213.
Fluorescence, III. 160.
Fogs, IV. 50; Fog-signals, 52.
Food, Preservation of, II. 72.
Food of Man, under different conditions, I. 313; in relation to his Work, IV. 431, 681–3.
Forbes, E., on the Natural History of the British Seas, I. 17.
—— on the supposed Analogy between the Life of an Individual and the Duration of a Species, I. 193.
—— on some new Points in British Geology, I. 316.
—— on the Manifestation of Polarity in the Distribution of Beings in Time, I. 428.
Forbes, J. D., his Laws on Vibrations and Tones of Heated Bodies, I. 356.
—— on his Theory of Glaciers, II. 320, 545.
Force, Conservation of, II. 352; III. 347.
—— Tyndall on, III. 527.
—— Magnetic, III. 98, 169.
Forgery of Antiquities, IV. 356.
Fossils in Nova Scotia Coal-fields, I. 281.
Foucault's Pendulum Experiment, I. 70.
Frankland, E., on the Employment of Chemical Light for Artificial Illumination, I. 319.
—— on the Chemical Properties of Compounds and the Electrical Character of their Constituents, I. 451.
—— on the Production of Organic Bodies, II. 538.
—— on Combustion in Rarefied Air, III. 331.
—— on Artificial Illumination, IV. 16.
—— elected Professor of Chemistry, IV. 109.
—— on the Glacial Epoch, IV. 166.
—— on Recent Chemical Researches in the Royal Institution, IV. 309, 465.
—— on the Source of Muscular Power, IV. 661.
Franklin, B., Experiments on Absorption of Heat by Coloured Bodies, IV. 489.
Fraunhofer's Lines, III. 326.
Freeman, E., on the Principal Styles of Architecture, I. 268.
French Government presents "Documents Inédits sur l'Histoire de France," III. 241, 290.
Frog, Development of, I. 9.

Froude, J. A., on the Science of History, IV. 180.
Fullerian Professors of Physiology:
  T. Wharton Jones elected, I. 101.
  T. H. Huxley elected, II. 147.
  R. Owen elected, I. 561.
  John Marshall elected, III. 526.
  T. H. Huxley elected, IV. 468.

Gaine, W., Parchment Paper, II. 409, 411.
Gale's Method of rendering Gunpowder non-explosive, IV. 618.
Gas-fuel, III. 537.
Gas-furnaces, III. 536.
Gases, Transmission of Heat through, III. 155, 295, 404; IV. 147.
—— Comparison of various Luminous, I. 320–4.
Gaslight Improvements, IV. 17.
Gassiot, J. P., Experiments on Vacua, III. 7; Experiments with his Vacuum-tubes, &c. 172.
Gautier on the Solar Spots, I. 238.
Geisers of Iceland, I. 332.
Gemmation, on, II. 534.
Geological Time, on, I. 287, 428; III. 109.
Geology of the Alps, I. 31; Lake Superior, 154; London, 164; Ingleborough, 278; Nova Scotia, 281; Isle of Wight, &c. 316.
Gerhardt's Discovery of Anhydrous Organic Acids, I. 239.
German Gunpowder, IV. 617.
Gillett, W. S., Improvements in Microscopes, I. 403–405.
Glacial Epoch, IV. 166.
Glaciers, II. 320, 545; III. 72, 269.
Gladstone, J. H., on Chemical Affinity. I. 416.
—— on Gunpowder, II. 99.
—— on Chromatic Phenomena exhibited by Transmitted Light, II. 336.
—— on Shooting Stars and Meteors, III. 143.
—— on Fogs and Fog-signals, IV. 49.
Glaisher, J., on Aërial Scientific Research, IV. 65, 385.
Glass Furnaces, III. 538.
Glen-Roy, Parallel Roads of, III. 341.
Gold, Extraction of, from its Ores, I. 205; Large Nugget from California, 3.
Gold and Light, Relations of, II. 310, 444.
Gorilla, III. 10.
Gothic Architecture, III. 32.
Graham, T., on Dialysis, III. 422.
Grailich's Researches in Crystallography, III. 98.
Grant, J., Cooking Apparatus, III. 251.
—— on Military Cookery, II. 422.
Grape-fungus, *Oïdium Tuckeri*, I. 305.
Gratiolet's Researches on the Brain, III. 408.
Greek Coins as illustrating Greek Art, IV. 306.
Grove, W. R., on the Heating Effects of Electricity and Magnetism, I. 119.
—— on the Transmission of Electricity by Flame and Gases, I. 359.
—— on Perpetual Motion, II. 152.
—— on Molecular Impressions of Light and Electricity, II. 458.
—— on the Electrical Discharge and its Stratified Appearance in Rarefied Media, III. 5.
—— on Boiling Water, IV. 158.
Gull, W. W., on Voluntary Movement, I. 37,
Gun-cotton, its Chemical History, &c. IV. 245; and Mechanical Nature, 292; improved, 622.
Gunpowder and its Substitutes, II. 99; IV. 616.

Halicarnassus, Discoveries at, III. 385.
Hall, Sir B., Present from, II. 315.
Haller on the Nervous Agent, IV. 577.
Hamilton, W. R. presents Lepsius' Egypt, II. 414.
Harton Colliery Experiments, II. 17.
Health and Houses, III. 133.
Haughton, S., Shot Drill Physiological Experiments, IV. 678.
Heat, Conduction of, I, 254.
—— in relation to Crystallography, III. 99; its Transmission through Gases, 155, 295.
—— of the Sun, Theory respecting, III. 531.
—— Application of, to Cookery, II. 422.
—— and Light, Analogies of, I. 172.
Heating Effects of Electricity and Magnetism, I. 119.
Heliograph, III. 363.
Helmholtz, H., on the Law of the Conservation of Force applied to Organic Nature, III. 347; IV. 675.
—— on Transmission by the Nerves, IV. 578.
—— his Myographion, IV. 582.
—— on Fluorescence in the Human Eye, IV. 571.
Herschel, A. S., on Luminous Meteors, &c. IV. 87, 644.

Herschel, J., on Chemical Rays of Light, I. 259.
Hill, M. D., on the Post-office, III. 457.
Hirsch, on the Nervous Agent, IV. 586, 590, 592.
History, Science of, IV. 180.
Hochstädter's Substitute for Gunpowder, IV. 617.
Hofmann, A. W., on Ammonia, II. 274.
—— on Mauve and Magenta, III. 468.
—— on the Combining Power of Atoms, IV. 401.
Holland, Sir H., Letter and Donations from, III. 107, 382, 526; IV. 177, 316, 464, 660; elected President, 434.
Holmes's Magneto-Electric Light Apparatus, III. 222; IV. 17.
Holy Sepulchre at Jerusalem, Site of, III. 426; IV. 366.
Hopkins, W., on the Earth's Internal Temperature, &c. III. 139.
—— on the Motion of Glaciers, III. 410.
Horizontal Shell-Firing, III. 504.
Horsley and Ehrhardt, Substitutes for Gunpowder, IV. 617.
Hosking, W., on Ventilation by the Parlour Fire, I. 76.
Houses in relation to Health, III. 133.
Huggins, W., on the Physical and Chemical Constitution of the Fixed Stars and Nebulæ, IV. 441.
Huxley, T. H., on Animal Individuality, I. 184.
—— on the Identity of Structure of Plants and Animals, I. 298.
—— on the Common Plan of Animal Forms, I. 444.
—— on Development of Animal Life in Time, II. 82.
—— on Natural History, II. 187.
—— on our Knowledge of Nerve, II. 432.
—— on Gemmation, II. 534.
—— on Persistent Types of Animal Life, III. 151.
—— on Species and Races, III. 195.
—— on the Earliest Stages in the Development of Animals, III. 315.
—— on Fossil Remains of Man, III. 420.
—— on the Methods and Results of Ethnology, IV. 461.
—— elected Fullerian Professor of Physiology, II. 147; IV. 468.
Hydro-carbons, on, II. 63.
Hydrogen and its Homologues, I. 325.

Ice, Physical Properties of, II. 454, 545.
Iceland, Eruptive Phenomena of, I. 329.
Iguanodon, Structure of, I. 141.
Illumination, Artificial, IV. 16.
—— by Chemical Light, I. 319.
India-Rubber, Properties and Applications of, I. 42; III. 250.
Indium, Discovery of, IV. 284.
Individuality, Animal, I. 184, 193
Ingleborough, Geological Sketches round, I. 278.
Insanity, Characters of, I. 375.
Insects, Metamorphoses of, III. 375; IV. 551.
Iron Age, IV. 33.
Iron and its Resistance to Projectiles, III. 491, 500.
—— Manufacture of, I. 434.
—— Walls of England, III. 503.
Invisible Rays, Combustion by, IV. 329.

Jacquard Loom, III. 271.
James, H., on Ordnance Survey, II. 516.
—— on the Ordnance Survey of Jerusalem, IV. 526.
Japanese Art, IV. 99.
Jekyll, E., on Siege Operations, II. 42.
Jerusalem, Discoveries at, &c. IV. 23, 366, 526.
Jones, H. B., on the Acidity, Sweetness, and Strength of Wines, I. 381.
—— on Ventilation, II. 236.
—— elected Hon. Secretary, III. 293.
—— on the Chemical Circulation in the Body, IV. 449
—— on the Existence in the Textures of Animals of a Fluorescent Substance closely resembling Quinine, IV. 564.
Jones, T. Wharton, obtains Actonian Prize, I. 54.
—— elected Fullerian Professor of Physiology, I. 101.
Joule, J. S., Researches on Heat, II. 202.

Kars, Siege of, II. 246.
Kent's Cavern, Torquay described, IV. 534.
Kew Observatory, its Work, IV. 58.
Kirchhoff's Spectrum Observations, III. 233, 395.
Knoblauch's Researches on Heat, I. 178.
Koh-i-nur Diamond, its History, III. 231.
Kyhl, P., Nature-Printing, II. 110.

Laboratory of Royal Institution, Assistants engaged, IV. 156; recent researches in, see *Faraday, Frankland, Tyndall.*
Lacaita, J. P., on Dante, II. 118.
—— on Earthquakes in Southern Italy, II. 528.

Lake-Habitations of Switzerland, IV. 29.
Lake Superior described, I. 154.
Lamont on Magnetic Variation, I. 238.
Lankester E., on the Limits of the Vegetable and Animal Kingdoms, I. 415.
—— on the Drinking Waters of the Metropolis, II. 466.
—— on Bread-making, III. 253.
Laurentian Rocks, IV. 374.
Lava, Consolidation of, III. 125.
Lectures, Courses (1851) I. 29; (1852) 103, 139; (1853) 227, 276 (1854) 344, 420; (1855) II. 5, 56; (1856) 150, 205; (1857) 318, 414 (1858) 452, 488; (1859) III. 4, 107; (1860) 168, 217; (1861) 294, 329; (1862) 399; (1863) III. 542; (1864) IV. 157; (1865) 328; (1866) 485.
Legacy from R. Horsman Solly, II. 526; from Beriah Botfield, IV. 326; from George Dodd, 346.
Leighton, J., on Japanese Art, IV. 99.
Lenk's Improvements in Gun-cotton, IV. 246, 296, 622.
Leyden Battery, Currents of, II. 132.
Library, Time of Admission to, enlarged, and Assistant in, provided, I. 89.
—— New Catalogue completed, II. 446.
Liebig, J., on Source of Muscular Power, IV. 661.
Life, Chronometry of, III. 117.
Light, Change of Refrangibility of, I. 259.
—— Chemical Action of, II. 223, 343; relations of Light and Gold, 310, 444; Chromatic Phenomena from Transmitted Light, 336; in relation to Crystals, III. 100.
—— and Heat, Analogies of, I. 172.
Lighthouse Illumination, III. 220.
Lighthouses, their Construction and mode of Lighting, I. 24.
Liquids, on Motion of, I. 446.
Lissajous' Acoustic Experiments, II. 441.
Lithium, III. 84; its Circulation in the Human Body, IV. 452.
Lochaber, Parallel Roads of, III. 341.
Locks, Improvements in, II. 475.
Louis of Hesse, Prince, elected Honorary Member, IV. 141, 151.
Lubbock, Sir John, on the Ancient Lake-Habitations of Switzerland, IV. 29.
—— on the Metamorphoses of Insects, IV. 551.
Lycurgus' Agrarian Laws, IV. 268.
Lyell, Sir C., on Impressions of Raindrops, I. 50.
Lyell, Sir C., on the Blackheath Pebble-bed, I. 164.
—— on Discoveries in the Coal Measures of Nova Scotia, I. 281.
—— on Geological Time, I. 287.
—— on Erratic Blocks in Massachusetts, II. 86.
—— on the Temple of Serapis, II. 207.
—— on Conical Form of Volcanoes, &c., III. 125.

MACFARREN, G. A., on the Music of the Church of England, IV. 594.
Magenta, History of, III. 468, 478; Specimens, 483.
—— its Derivatives, IV. 437.
Magnesium, III. 82; presented, IV. 151; Light, 489.
Magnetic Characters of Oxygen and Nitrogen, I. 1.
—— Disturbances, IV. 55.
—— Experiment, IV. 317.
—— Force, Physical Lines of, I. 105, 216, 229; Influence of Material Aggregation on, 254; its Influence on the Electric Discharge, III. 169.
—— Hypotheses, I. 457.
—— Relations of Crystals, III. 98.
Magnetism, II. 6, 13, 159, 196, 352.
—— Atmospheric, I. 56.
—— Heating effects of, I. 119.
Magneto-Electricity applied to Lighthouses, III. 222.
Magnets—Hæcker's, I. 28; Logeman's, 37, 230.
Magnus on Rotatory Motion, I. 395.
Malone, T. A., on Photogalvanography, II. 343.
Malvern Hills, II. 386.
Mammalia, Geographical Distribution of, III. 109; Cerebral System of Classification, 174.
Man, as distinguished from Apes by his Structure, III. 15; by his Brain, 407; Fossil Remains of, 420.
Mantell, G. A., on the Iguanodon, and on the Fauna and Flora of the Wealden Formation, I. 141.
Marshall, J., elected Fullerian Professor of Philosophy, III. 526.
Maskelyne, N. S., on the Connection of Chemical Forces with the Polarization of Light, I. 45.
—— on the Crystal Molecule, III. 95.
—— on Diamonds, III. 229.
Massachusetts Erratic Blocks, II. 86.
Masters, M. T., on Abnormal and Normal Formations in Plants, III. 223.
Material Aggregation, I. 254.

Material Medium in Space, iv. 558.
Maurice, F. D., on Milton as a Schoolmaster, ii. 328.
Mausoleum at Halicarnassus, iii. 384.
Mauve, its Chemical History, iii. 468; iv. 438.
Maxwell, J. C., on the Theory of Three Primary Colours, iii. 370.
Mayer's Researches on Heat, Force, &c., iii. 534; iv. 663.
Mayo, T., on the Relations of the Public to the Science and Practice of Medicine, iii. 258.
Medusa Aurita, Development of, i. 11.
Melde's Experiments on the Vibration of Strings, iv. 687.
Mer-de-Glace, ii. 545.
Metals, Ancient and Modern, ii. 215; Precipitation of, iii. 81.
Metamorphoses and Metageneses of Animals, i. 9; iv. 551.
Metamorphoses of Insects, iii. 375; iv.
Meteorological Telegraphy, iii. 444.
Melting Points of Sulphur, i. 449.
Mercer's Contraction of Cotton by Alkalies, i. 134.
'Merrimac' described, iii. 508.
Meteorology of Torquay, ii. 437.
Meteors, iii. 143, 531.
—— Luminous, iv. 87, 644.
Microscopes, Construction of, i. 402.
Military Chemistry, ii. 283; Cookery, 422.
Miller, W. A., on the Photographic Transparency of Bodies, and on the Photographic Spectra of the Elementary Bodies, iv. 42.
—— Stellar Spectrum Observations, iv. 442.
Milnes, R. Monckton, on International Exhibition of 1862, iii. 485.
Military Books presented, iii. 275.
Milton as a Schoolmaster, ii. 328.
Minerals of the Andes, iii. 190.
Mining Districts of North of England, ii. 57.
Mirage, i. 67.
Mitchell, Rev. W., on Crystallography, iii. 86.
Molecular Physics, iv. 233.
Molecule of Water, iv. 118.
'Monitor' described, iii. 509.
Monuments in Westminster Abbey, iv. 602.
Moon's Surface, Physical Aspects of, iv. 300.
More, H., on Man, ii. 26, 41.
Motion in Plants and Animals compared, iii. 433.
Motive Power, ii. 152, 199.
Movement, Voluntary, Physiology of, i. 37, 147.
Mud Volcanoes and Petroleum, iv. 629.
Müller, M., on the Vedas, iv. 135.
Muller, H., Chemical Discoveries, ii. 506, 508.
Munk, H., on Transmission by the Nerves, iv. 585.
Murchison, Sir R. I., on the Changes of the Alps, i. 31.
—— Annual Donation, iv. 108.
Murray, R., sets up Penny-Post, iii. 458.
Muscular Power, Source of, iv. 661.
Music of the Church of England, iv. 594.
Music and English Poetry, iii. 317.
Myographion, iv. 582, 583.

Nasmyth, J., on the Physical Aspects of the Moon's Surface, iv. 300.
Nature-Printing, ii. 106.
Nebulæ, their Constitution, iv. 441.
Nerve-centres, iv. 207.
Nerves, our present Knowledge of, ii. 432; their Nutrition and Reparation, iii. 378; Time required for Transmission by, iv. 575.
Nervous Agent, iv. 576.
New Bond Street, No. 166, purchased, iv. 291.
New Zealand, Earthquake at, ii. 213.
Newton, J., on Gravitation, i. 237.
Newton, C. T., on the Mausoleum at Halicarnassus, iii. 384.
Nile, Sources of, iv. 492.
Nitrogen, its Magnetic Character, i. 2.
Nitro-glycerine, iv. 620.
Noad, Dr. H. M., on the Manufacture of Iron, i. 434.
Nobel, A., on Nitro-glycerine, iv. 620.
Northern Plants, Distribution of, iii. 431.
Northumberland, Duke of, the President, Decease of, iv. 356, 372.

Odling, W., on the Hydro-carbons, ii. 63.
—— on Magnesium, &c. iii. 80.
—— on Acids and Salts, iii. 234.
—— on Graham's Researches on Dialysis, iii. 422.
—— on the Molecule of Water, iv. 118.
—— on Aluminium Ethide and Methide, iv. 343.
—— on Source of Muscular Power, iv. 662.
Oliver, D., on the Distribution of Northern Plants, iii. 431.

Opalescence of the Atmosphere, IV. 651.
Oral Reading, IV. 242.
Ordnance Survey, II. 516; of Jerusalem, IV. 526.
Organic Bodies, Production of, II. 538; detected by their Optical Properties, IV. 223.
Organic Chemistry in Royal Institution, IV. 309, 465; Organic Synthesis, 199.
Overstone, Lord, presents a 'Collection of Tracts,' III. 218.
Owen, R., on Metamorphosis and Metagenesis, I. 9.
—— on the Structure and Homologies of Teeth, I. 365.
—— on Anthropoid Apes, and their Relation to Man, II. 26.
—— on Ruminant Quadrupeds, II. 256.
—— elected Fullerian Professor, II. 561.
—— on the Gorilla, III. 10.
—— on Succession in Time and the Geographical Distribution of Mammalia, III. 109.
—— on Cerebral Classification of Mammalia, III. 174.
—— on a National Museum of Natural History (*no abstract*), III. 360.
Oxygen, its Magnetic Character, I. 1; Boussingault's Mode of preparing, 337.
Ozone, its Production and Properties, I. 94.
Ozone and Antozone, M. Faraday on, III. 70.

PAGET, James, on the Chronometry of Life, III. 117.
Palgrave, W. G., on Central and Eastern Arabia, IV. 348.
Palmer, John, improves Postal System, III. 459.
Paraffin, I. 6, 7; 135.
—— Oil, &c. IV. 19, 20.
Parallel Roads of Lochaber, III. 341.
Parchment Paper, II. 409.
Paris, Comte de, Letter from, respecting the Prince Consort, III. 430*a*.
Paternò Volcanic Eruption, IV. 629, 640.
Peat and its Products, I. 4.
Pectous State of Bodies, III. 425.
Pendulum Experiments, I. 70; at Harton, II. 17.
Pengelly, W., on the Ossiferous Caverns of Devonshire, III. 149.
—— on Devonian Fossils and the Burdett-Coutts Geological Scholarships, &c., III. 263.
—— on Kent's Cavern, Torquay, IV. 534.
Penny Post established, III. 458, 461.
Penrose, F., on some relations of Science to Architecture, I. 124.
Peptous State of Bodies, III. 425.
Pepys, J., Donations from, I. 54, 455.
Percy, J., on the Modes of extracting Gold from its Ores, I. 205.
—— on Recent Improvements in the Smelting of Iron and the Manufacture of Steel (*no abstract*), IV. 244.
Perkin, W. H., isolates the Mauve Colour, III. 478; IV. 438.
Perpetual Motion, on, II. 152.
Petitjean's Silvering Process, II. 308.
Permian Epoch, Climate of, II. 417.
Petroleum, Manufactures from, II. 506; relation to Mud Volcanoes, IV. 633.
Phillips, J., Geological Sketches round Ingleborough, I. 278.
—— on the Malvern Hills, II. 385.
Phosphorus, Allotropic Modifications of, I. 135, 203.
Phosphorescence, III. 159.
Phosphoroscope, III. 161.
Photogalvanography, II. 343.
Photographic Eclipse Results, III. 362.
—— Transparency of Bodies, IV. 43.
Pickersgill, H. W., paints and presents Portrait of Rev. J. Barlow, III. 1.
Pierotti's Discoveries at Jerusalem, IV. 23.
Pigeons, on various Breeds of, III. 197.
Plants, Electric Currents in, I. 75; Growth of in Cases, 407; their Abnormal and Normal Formations, III. 223.
Platinum, III. 321; Deville's Process for obtaining it, 322.
Playfair, Dr. L., on Chemical Discoveries from the Exhibition of 1851, I. 131.
—— on the Food of Man under different Conditions of Age and Employment, I. 313.
—— on Chemistry of Agriculture, II. 289.
—— on the Food of Man in relation to his Useful Work, IV. 431, 662, 678
Ploughs and Ploughing, I. 265.
Pocy's Researches on Meteors, III. 144.
Polarity (in Natural History and Geology), I. 428.
Polarization of Light, connection of Chemical forces with, I. 45.
Poole, R. S., on Greek Coins as illustrating Greek Art, IV. 306.
Portraiture, English Historical, its Fallacies, &c. IV. 543.
Post-office, History of, III. 457.

Chronoscope, IV. 577.
rof. Baden, on Foucault's Pen-
Experiment, I. 70.
e Analogies of Light and
. 172.
otatory Motion, I. 393.
otatory Stability, II. 480.
hooting Stars, III. 144.
Manufacture of Gun-cotton,

Lists of, under General
y Meetings, *throughout the*

P., Photogalvanography, II.

, J., on the Flint Implements
eville. IV. 213.
, C., on the Telescope, IV.

e in Animals, IV. 564.

s through Air, IV. 4, 233.
Absorption, with reference to
of Bodies and their State of
gation, IV. 487.
ps, Impressions of, I. 50.
A. C., on Climate of the Per-
Epoch, II. 417.
Geology of Canada, &c. II. 522.
the Eozoön and the Laurentian
of Canada, IV. 374.
Air, Combustion in, III. 331.
n, H. C., on Cuneiform In-
ons at Babylon and Nineveh,
III. 536.
Excavations in Assyria and
on, II. 143.
the Results of Cuneiform Dis-
up to the present Time, IV.

l, J., Experiments on Fluor-
e in Animals, IV. 571.
l Type of Animal Life, II. 497.
on's Lifeboat, I. 221.
l, Electrical Researches, II.

described, IV. 137.
xperiments on the Magnetic
and Electric Discharge, III.

H. D., Geology of North
a, II. 167.
he Parallel Roads of Glen Roy,

, G., on the Brain of Man and
Animals, III. 407.
H. E., on Chemical Action of
II. 223.

Roscoe, H. E., on the Measurement of the Chemical Action of the Solar Rays, III. 210.
—— on Bunsen and Kirchhoff's Spectrum Observations, III. 323.
—— on the Direct Measurement of the Sun's Chemical Action, IV. 128.
—— on the Metal Indium, and Recent Discoveries in Spectrum Analysis, IV. 284.
—— on the Opalescence of the Atmosphere, IV. 651.
Rotation of Earth shown by the Pendulum, I. 70.
Rotatory Stability, on, II. 480.
—— Motion, Phenomena of, I. 393.
Roxburgh, W., on the Cartesian Barometer, I. 426.
Royal Institution Chemical Researches, IV. 309, 465.
Rubidium discovered, III. 326.
Ruhmkorff's Induction Apparatus, III. 139.
Ruminant Quadrupeds, on, III. 256.
Ruskin, J., on Tree Twigs, III. 358.
—— on the Forms of the Stratified Alps of Savoy, IV. 142.
Russell, John Scott, on Wave-line Ships and Yachts, I. 115.
—— on English Ships and American Clippers, 210.
—— on Iron Walls of England, III. 503.
—— on the Mechanical Nature and Uses of Gun-Cotton, IV. 292.

SABINE, E., on Atmospheric Magnetism, I. 238.
St. Peter's, at Rome, aided by Science, IV. 12.
Salmon, W., Botanical Works presented by, III. 193.
Salts and Acids, III. 234.
Sandwith, H., on Siege of Kars, II. 246.
Sap, Rise of, I. 197.
Savage, Miss A., presents her Father's Works on Printing in Colours, II. 333.
Savart's Researches, I. 447.
Savory, W. S., on the Relation of the Vegetable and Animal to the Inorganic Kingdom, III. 368.
—— on Motion in Plants and Animals, III. 433.
—— on Dreaming and Somnambulism, IV. 207.
Scharf, G., on Portraiture: its Fallacies and Curiosities as connected with English History, IV. 543.

Schehallien Experiment, II. 18.
Schelske, on Nervous Agent, IV. 587, 590.
Schönbein's Ozone, I. 94.
—— Experiments on Variations of the Colour of Bodies, I. 400.
—— on Ozone and Antozone, III. 70.
Schrötter's Amorphous Phosphorus, I. 135.
Schultze's Gun-sawdust, IV. 621.
Schwabe's Observations of Spots on the Sun, I. 237.
Science as a Branch of Education, II. 556; applied to Calico Printing, III. 201; to Military Purposes, 243.
Science of History, IV. 180.
Scott, A. J., Physics and Metaphysics (*no abstract*), II. 439.
Secretary—Rev. J. Barlow resigns, III. 291; Dr. H. Bence Jones elected, 293.
Serapis, Temple of, Changes in, II. 207.
Setschenow, I., Experiments on Fluorescence in Animals, IV. 591.
Shakespeare, Cardinal Wiseman on, IV. 470.
Shepherd's Electro-magnetic Clocks, I. 109.
Sherwoodole, II. 507.
Shippard, Captain W. H., on Central America and the Ship-Canal, I. 75.
Ships and Yachts, English and American, I. 115, 210.
Shooting Stars, &c. III. 143; IV. 87, 644.
Shot-drill Experiments, IV. 679.
Sidney, E., on the Rise of the Sap in the Spring, I. 197.
Siege Operations, II. 42.
Siemens, C. W., on the Regenerative Steam-engine, II. 227,
—— Gas Furnaces, &c. III. 536.
Silica, its Use in the Arts, I. 422.
Sitaris Beetle, Metamorphoses of, IV. 553.
Smith, A., on the Deviation of the Compass in Iron Ships, IV. 518.
Smith, E., Researches on Animal Work, III. 355; IV. 676.
Smith, Robt. Angus, on Organic Matter in the Air, III. 89.
Smyth, Piazzi, Rotatory Apparatus, II. 485.
—— Ascent of Peak of Teneriffe, II. 493.
Smyth, W. W., on Coal, III. 510.
Sobrero discovers Nitro-glycerine, IV. 620.
Sodium presented, IV. 153.
Soils of England, Properties of, IV. 110.
Solar Rays, Chemical Action of, III. 210, 387.
—— Spots, Observations of, I. 237.
Solly, R. H., Legacy from, II. 526.
Solly, S. R., Annual Donation, IV. 109.
Somnambulism, IV. 210.
Sonsted, Mr., presents Specimens of Magnesium, IV. 151.
Sopwith, T., on Mining Districts of North of England, II. 57.
Sorby, H., on Cleavage, II. 308.
Sotheby, S. L., presents 'Principia Typographica,' III. 167.
Sources of the Nile, IV. 492.
Spartan Constitution, &c. IV. 263.
Species and Races, their Origin, III. 125.
Spectra of Elementary Bodies, IV. 46.
Spectrum Analysis, III. 323; recent Discoveries in, IV. 284.
Speke, Captain, on the Discovery of the Source of the Nile (*no abstract*), IV. 150.
Spheroidal State of Liquids, I. 179.
Spottiswoode, W., elected Treasurer, IV. 434.
Stanhope, Earl, on the Influence of Arabic Philosophy in Mediæval Europe, IV. 506.
Stanley, Dean, on Westminster Abbey, IV. 598.
Statham's Arrangement of Electric Telegraph Wire for Experimental Purposes, I. 346; his Fuze, 347, 355.
Steam-engine, Regenerative, II. 227.
Stenhouse, J., on the Applications of Charcoal to Sanitary Purposes, II. 53.
Stethophone, III. 63.
Stevens's Battery, III. 508.
Stevenson, Mr., on Auroræ Boreales, I. 274.
Stewart, Balfour, on the Forces concerned in producing Magnetic Disturbances, IV. 55.
—— on the latest Discoveries concerning the Sun's Surface, IV. 378.
—— on the Existence of a Material Medium pervading Space, IV. 558.
Stokes, G. G., on the Refrangibility of Light, I. 259.
—— Researches on Fluorescence, III. 160; IV. 564.
—— on the Discrimination of Organic Bodies by their Optical Properties, IV. 223.
Stone Age, IV. 31.
Suggestion, its Influence on Movement, I. 147.
Sulphur, its Allotropic Modifications, I. 202; and Melting Points, 449.

Sun. Physical Character of, III. 327, 387; Total Eclipse of, 362; Theory of the Origin of its Heat, 533; Chemical Action of, its Measurement, IV. 128, 654; latest Discoveries respecting its Surface, IV. 378.
Synthesis of Organic Bodies, IV. 199.
Synthetically-formed Substances by the Plant or by the Chemist, IV. 568.

TALBOT, H. Fox, Photographic Engraving, II. 347.
Taylor, Rev. W., on Educating the Blind, I. 290.
Teeth, Structure and Homologies of, I. 365.
Telegraph, Submarine, II. 394.
Telescope, its modern form, &c., IV. 641.
Temple of Jerusalem, IV. 366.
Thallium discovered, IV. 62.
Time, Geological, I. 287, 428.
—— required for Transmission by the Nerves, IV. 575.
Thomson, W., on Motive Power, II. 199.
—— on Atmospheric Electricity, III. 277.
Treadwheel Work, IV. 676.
Tree Twigs, J. Ruskin on, III. 358.
Trilobites, Theory respecting, III. 268.
Twining, Miss Eliz., presents her Works on Plants, III. 107.
Tyndall, John, on the Influence of Material Aggregation upon the Manifestations of Force, I. 254.
—— on the Eruptive Phenomena of Iceland, I. 329.
—— elected Professor of Natural Philosophy, I. 339.
—— on the Vibration and Tones produced by the Contact of Bodies having different Temperatures, I. 356.
—— on the Motion of Liquids, I. 446.
—— on the Magnetic and Diamagnetic Force, II. 13, 159.
—— on the Leyden Battery, II. 132.
—— on Cleavage of Rocks, &c. II. 295.
—— on Glaciers, II. 320.
—— on Lissajous' Acoustic Experiments, II. 441.
—— on the Physical Properties of Ice, II. 454.
—— on the Mer-de-Glace, II. 545.
—— on the Veined Structure of Glaciers, III. 72.
—— on Transmission of Heat through Gases, III. 155.
Tyndall, John, on the Influence of the Magnetic Force on the Electric Discharge, III. 169.
—— on some Alpine Phenomena, III. 269.
—— on the Action of Gases and Vapours on Radiant Heat, III. 295.
—— on the Physical Basis of Solar Chemistry, III. 387.
—— on the Absorption and Radiation of Heat by Gaseous Matter, III. 404.
—— on Force, III. 527.
—— on Radiation through the Earth's Atmosphere, IV. 4.
—— an Account of some Researches on Radiant Heat, IV. 146.
—— Contributions to Molecular Physics, IV. 233.
—— on a Magnetic Experiment, IV. 317.
—— on Combustion by Invisible Rays, IV. 329.
—— on Radiation and Absorption, with reference to the Colour of Bodies, and their State of Aggregation, IV. 487.
—— Experiments on the Vibrations of Strings, IV. 685.

UNGULATA, Owen's List of, II. 260.

VACUA, Peculiar, how prepared, III. 9; Electric Discharge in, 6, 7.
Vapours, their action on Radiant Heat, III. 295, 406; IV. 5, 149, 488.
Vedas, the Sacred Books of the Hindus, IV. 135.
Vegetable, Animal, and Inorganic Kingdoms, their Relations, III. 368.
Velocities of Electricity, Light, Sound, Nervous Agent, &c. IV. 588.
Ventilation, on, II. 236; by the Parlour Fire, I. 761.
Vibrations of Strings, IV. 685.
Vital and Physical Forces, their Relations, III. 206.
Vivian, E., on Meteorology and a Balloon Ascent, II. 437.
Voelcker, A., on some Chemical and Physical Properties of Soils, and the Productive Powers of the Soils of England, IV. 110.
Volcanoes, Conical Form of, III. 125.
Voluntary Movement, Physiology of, I. 37, 147.
Von Lang's Researches in Crystallography, III. 98.
Vrolik on Apes, III. 16.

WALES, Prince of, Elected Honorary Member and Vice-Patron, IV. 3, 13; Present from, 176.
Walker, A. De Noè, presents a Chinese Library, III. 219.
Walker, C. V., Railway Telegraph Signals, II. 403.
Waller, A., on the Nutrition and Reparation of Nerves, III. 378.
Wallich, G. C., on the Nature of the Deep-sea Bed, and the Presence of Animal Life at vast Depths in the Ocean, III. 299.
Ward, S. H., on the Growth of Plants, in closely glazed Cases, I. 407.
Warington, R., on the Aquarium, II. 403.
Warington, Geo., obtains Actonian Prize, IV. 399.
Warner, Messrs., Bell-founding, II. 380.
Wanklyn, J. A., on the Synthesis of Organic Bodies, IV. 199.
'Warrior' described, III. 508.
Water, Molecule of, IV. 118.
—— Supply of London, II. 47, 466.
Wave-line Ships and Yachts, I. 115, 210.
Wealden Formation, Fauna and Flora of, I. 141.
Wellington, Duke of, Cast of his Features after Death presented, III. 274.
Westmacott, R., on Art-Education, and how Works of Art should be viewed, IV. 381.
Westminster, Dean of, on Westminster Abbey, IV. 598.
Westminster Bell, II. 368.
Westwood, J. O., on Metamorphoses of Insects, III. 375.
White Gunpowder, IV. 617.
Whitworth Gun, III. 248.
Wheatstone's Electric Telegraph, II. 394, 556.
Williams, G., on Recent Discoveries at Jerusalem, IV. 23.
Williamson, A. W., on Etherification, I. 90.
—— on Gerhardt's Discovery of the Anhydrous Acids, I. 239.
—— on the Classification of the Elements in relation to their Atomicities, IV. 274.
Wilson, John, on Ploughs and Ploughing, I. 265.
Wines, Treatment of, I. 303; Acidity, Sweetness, and Strength of, 381.
Wiseman, Cardinal, on the Points of Contact between Science and Art, IV. 8.
—— on Shakespeare, IV. 470.
Wislicenus, Dr., on Source of Muscular Power, IV. 664 *et seq.*
Women, their Influence on the Progress of Knowledge, II. 504.
Woody Fibre, on, II. 409.

YOUNG's Paraffine, I. 135.

ZINC-ETHYL, its Power, IV. 311.

END OF VOL. IV.

London: Printed by W. CLOWES & SONS, Stamford Street and Charing Cross.

UNIVERSITY OF MICHIGAN
3 9015 03545 3383